

# BRIGHT SPARKS

## INSPIRING INDIAN SCIENTISTS FROM THE PAST



by Arvind Gupta

illustrated by Karen Haydock

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## FOREWORD

It is with great pleasure that I commend to readers, particularly young ones, *BRIGHT SPARKS*, written so beautifully by Arvind Gupta and illustrated equally beautifully by Karen Haydock. As part of the Platinum Jubilee celebrations, the Indian National Science Academy (INSA) has been pursuing a vigorous publication programme this year. Most of the publications we have brought out are scholarly scientific volumes. We also felt the need for a publication to introduce in an appealing manner great past Indian scientists to the public, especially the young. It was when I was toying with this idea that I happened to chair the lecture by Arvind Gupta when he received the INSA Indira Gandhi Award for Science Popularisation on Science Day in February, 2008. After listening to him, I had no doubt as to whom we should invite to write such a book. Arvind Gupta graciously accepted our invitation to do so. He recruited the services of Karen Haydock to prepare illustrations. My distinguished colleagues Jayant Narlikar, Madhav Gadgil and T. Padmanabhan kindly agreed to function as an Advisory Committee in the preparation of the book. All then worked well and we now have this wonderful book. I thank the author, the illustrator and the Advisory Committee for producing it. I am sure it would inform, inspire and entertain a wide cross section of children and adults.

M. Vijayan  
President  
Indian National Science Academy

# Introduction

The idea of this book was born on the National Science Day (28 Feb 2008) at the Indian National Science Academy (INSA), New Delhi. I was there to receive the *Indira Gandhi Award for Science Popularisation* from Prof. M. Vijayan – President of INSA. In a brief conversation Prof. Vijayan requested me to write a popular book on past Indian scientists as part of INSA's Platinum Jubilee Celebrations. The brief given was to write “*a thoroughly readable book with good visual content so that it appeals to children.*”

Prof. Vijayan pursued it seriously. A few days later he contacted Prof. Jayant Narlikar – who agreed to Chair and steer the advisory panel. Prof. Narlikar in turn roped in Prof. Madhav Gadgil and Prof. T. Padmanabhan as panel members. I am deeply indebted to this extremely eminent advisory panel – all great scientists and also very sensitive human beings.

## Choice of scientists

After a couple of meetings a list of 40 past scientists was homed upon. How were they chosen? The first criterion was to include all those who had won the Nobel Prize – undoubtedly the world's greatest award. The second criterion was to include all those who had been elected as Fellows of the Royal Society (FRS). Nain Singh Rawat's name was suggested as a pioneering surveyor – someone who surveyed large tracts of the Himalayas - Tibet and Lhasa in which the British had themselves failed. For this feat he was bequeathed the Victoria Medal. INSA suggested the names of Ruchi Ram Sahni – a pioneering science populariser from Punjab and Yellapragada SubbaRow – whose discovery of the antibiotic *tetracycline* saved millions of lives throughout





the world. Salim Ali – India’s most famous ‘*Birdman*’ and Vikram Sarabhai – architect of India’s Space Programme were of course included. Some unsung heroes were added to the list - D. D. Kosambi – Mathematician and Indologist, Shirodkar – inventor of the *Shirodkar Stitch*, P. K. Sethi designer of the world famous *Jaipur Foot*, environmentalist Anil Agarwal and Laurie Baker – who built houses for the millions. I was privileged to be apprenticed under Laurie Baker. So I was elated when his name was included.

### Why so few women?

“*Where are the women scientists?*” asked Prof. Gadgil and suggested the inclusion of Irawati Karve as a pioneering anthropologist. As luck would have it a landmark book *Lilavati’s Daughters* was just published. This pioneering book documented the experiences and struggles of 100 women Indian scientists. This helped us add the names of Anna Mani and Kamala Sohoni two pioneering women who struggled very hard to make a mark in the world of science dominated by men.



This brings us to the very moot point – why only three women in a galaxy of 40 eminent scientists? Why not twenty out of forty? For one - odds were heavily stacked against women. There was a general consensus in society at that time that education for women should be tailored to their roles as women and homemakers. In a feudal and patriarchal society only a select and privileged group of women belonging to the high caste/class had access to higher education. Even this minority had to struggle hard to gain entry into the magical world of science.



Kamala Sohoni the topper of Bombay University was refused admission by Sir C. V. Raman – India’s Nobel Laureate. “*I am not going to take any girls in my institute.*” When confronted, he finally relented and admitted Kamala though not as a regular student. Kamala distinguished herself and later earned a PhD from Cambridge. The few defiant women who triumphed had to struggle against all odds to gain acceptance in the male-dominated world of science. Their struggles and sacrifices paved way for other

women. Things have changed and according to one estimate there are over a million women scientists in India today. The fact that one out of four scientists in India today is a woman is something to rejoice.



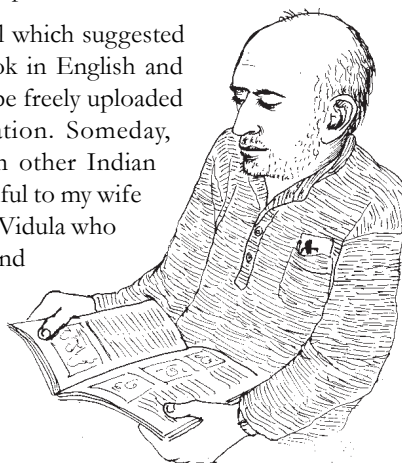
After taking up the task I got sucked into it and enjoyed it immensely. I was singularly fortunate to get Dr. Karen Haydock to illustrate and design the book. Karen is a biophysicist who has been in India for over two decades. Both her parents were artists. Her sensitive and realistic illustrations had imbued the *Hoshangabad Science* activity books with life. Once she agreed to illustrate and design I was assured of a first-rate book. My own attempts at writing this book have been modest. If at all this book will be read widely it will be because of the very unique presentation by Karen.



The stereotypical image of a scientist is that of a uni-dimensional man immersed in his lab, cut-off from the wider world. But, scientists like other human beings have many facets to their character. I have attempted to give their life-sketches along with their contributions. Did a childhood experience inspire them to take up science? Was it a kindred teacher or the loving mother? A few vignettes of their human nature have been woven – some wrote poems, some sketched and some loved to speed on big motorbikes at full throttle! Interesting personal anecdotes have been added to lend depth to their character.

I am grateful to the Advisory Panel which suggested that apart from publishing the book in English and Hindi its digitized versions should be freely uploaded on the web for wider dissemination. Someday, hopefully this book will appear in other Indian languages too. I am extremely thankful to my wife Sunita and my wonderful colleague Vidula who suffered reading all what I wrote and suggested appropriate changes.

Arvind Gupta  
2nd October 2009  
email: arvindtoys@gmail.com



The word 'scientist' often conjures an image of an isolated man in a lab, surrounded by books, expensive instruments, test tubes, and beakers belching out strange fumes. But actually, scientists have many facets to their character. Some of the scientists in this book wrote stories and poems; others had a passion for art - while a few loved speeding around on motor bikes! Many scientists passionately engaged with the society outside their labs and worked hard to make the world a better place.

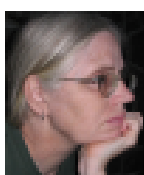
Apart from their life sketches interesting personal anecdotes have been added to lend depth to their character. What made them take up science? Did a childhood experience inspire them? Was it a kindred teacher or a loving parent? What odds did the men, and particularly the women have to face and overcome? Hopefully, their lives will inspire the young.

**Bright Sparks** chronicles the lives and contributions of 40 inspiring Indian scientists of the past.



**Arvind Gupta** is known throughout India as a science populariser and toymaker. He has conducted thousands of workshops in India and abroad, and made numerous TV shows on making science toys from 'junk'. He writes, translates, and shares his passion for books and toys through his popular website [arvindguptatoys.com](http://arvindguptatoys.com)

Arvind obtained a BTech from IIT Kanpur in 1975. He opted out of a lucrative career to devote his life to science popularisation. Currently, he works at the Muktagan Science Centre for Children located at the Inter-University Centre for Astronomy & Astrophysics (IUCAA) in Pune. He has been conferred numerous awards for his work, including the inaugural National Award for Science Popularisation amongst children (1988) and the Distinguished Alumnus Award by IIT / Kanpur (2000).



**Karen Haydock** has illustrated numerous books and textbooks for children during her last 20 years in India. In addition to her work as an artist, she has been teaching, training teachers, developing teaching methods, and writing books. She was originally trained as a biophysicist, having completed her PhD and post-doctoral research in USA.

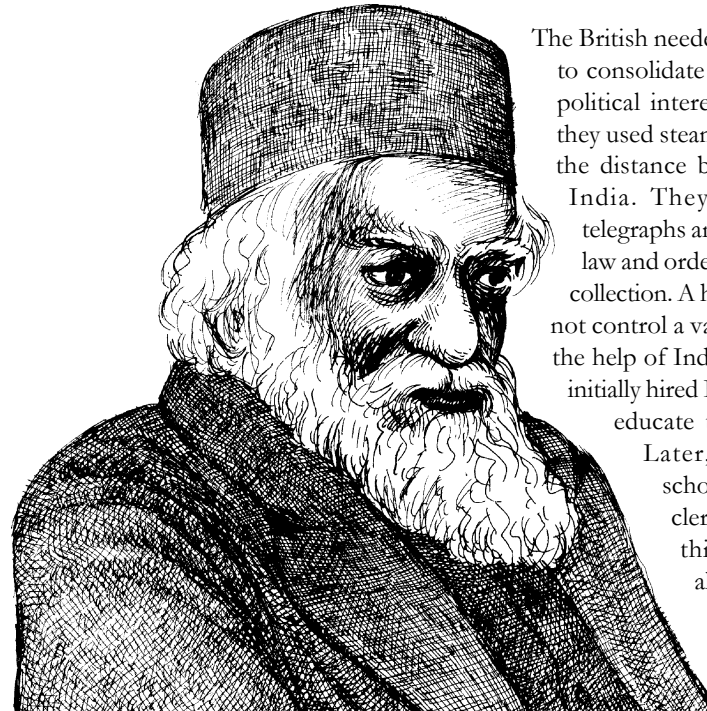


A publication of the Indian National Science Academy

# Ardaseer Cursetjee

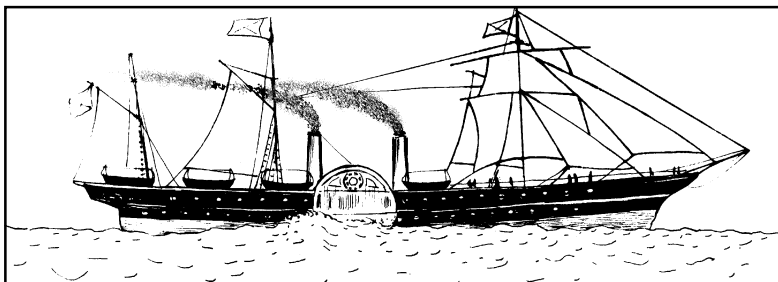
(1808 - 1877)

Few Indians would have ever heard the name of Ardaseer Cursetjee. Even fewer would know that this marine engineer from Bombay was the first Indian to become a fellow of the Royal Society - on 27 May, 1841. The next fellowship conferred on the famous mathematician - S. Ramanujan came only 75 years later!



The British needed modern technology to consolidate their commercial and political interests in India. For this they used steam navigation to reduce the distance between England and India. They laid a network of telegraphs and railways to maintain law and order and increase revenue collection. A handful of British could not control a vast India. They needed the help of Indians in this task. They initially hired Indians as informers to educate them about the land.

Later, the British set up schools to train Indians as clerks and calculators. But this modern education also laid the seeds of a national awakening in Indians.



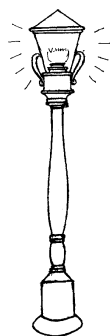
Cursetjee's family had a long history of service to the British in the field of shipbuilding. His ancestor Lowjee Nusserwanji (Wadia) was a carpenter at the Surat dockyard. Later the British brought him to Bombay to build a dockyard. The British built ships using oak logs. But soon the expansionist Empire ran out of oak trees. They found a better substitute for oak in the Malabar teak – it was strong and decay-resistant. With abundance of teak and skilled workers, Bombay emerged as a major ship-building centre. Shipbuilding brought great prestige to the Cursetjee family.

The use of the steam engine in navigation virtually coincided with Cursetjee's birth in the early 19th century. However, Cursetjee was more interested in steam machinery than in ship-building. He soon showed his mettle by building a 1-HP engine. It was installed in a well to pump water to a small fountain. This was the first engine built in India. In 1833, Cursetjee obtained a 10-HP marine engine from England and installed it in a vessel named *Indus*. In October 1833, he was made assistant builder at Mazagaon. Cursetjee maintained a small private foundry at his residence where he fabricated wrought-iron tanks for ships.

His next engineering feat was the installation of gas lighting. By 1834, he lighted his bungalow and gardens at Mazagaon, using gas.

Soon he was invited to teach practical sciences at the newly established Elphinstone Institute. He assisted the Institution 'in instructing the natives', especially in mechanical and chemical sciences. Three years later, he was elected a non-resident member of the Royal Asiatic Society of England.

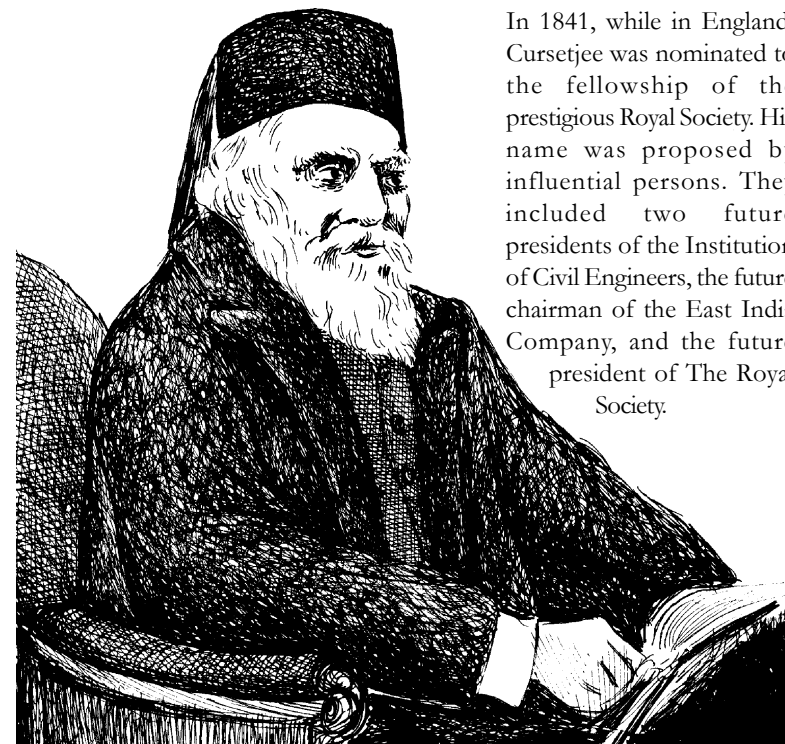
Cursetjee soon decided to spend a year in England. He wanted to learn the latest about marine steam engines. On this trip he



took his servants along, because he only ate food cooked by Parsis. In matters of religion, Cursetjee was a severe traditionalist. He did not approve of a young Parsi not donning the traditional cap in England. He was invited to attend a meeting of a House of Commons committee.

For all his hyperactivity though, Cursetjee was not too impressed by London. He found the royal mint considerably inferior to the one at Bombay. And he castigated London's "dirty roads", comparing them unfavourably with Bombay's.

Professionally, however, Cursetjee's British sojourn was very successful. He became an associate of the Institution of Civil Engineers, a member of the Society of Arts and Science, and of the mechanical section of the British Association for the Advancement of Science. He was appointed chief engineer and inspector of machinery in the Company's steam factory and foundry at Bombay. The post carried a salary of Rs 600 per month, more than seven times his then salary as an assistant builder.



In 1841, while in England, Cursetjee was nominated to the fellowship of the prestigious Royal Society. His name was proposed by influential persons. They included two future presidents of the Institution of Civil Engineers, the future chairman of the East India Company, and the future president of The Royal Society.

Today The Royal Society has a reputation of being an association of eminent scientists. But in the early decades of the twentieth century, The Royal Society was also a club of gentlemen *curious in natural history*, well acquainted with mathematics and engineering, or ‘conversant in various branches of experimental philosophy’. In terms of the norms then in vogue, the Society would have characterised Cursetjee as a distinguished engineer – and as a promoter of science.

Cursetjee’s fellowship of the Royal Society remained strictly a private honour. It did not advance his professional career in any way, nor did it impress his countrymen. In the meantime, he returned to Bombay, and took his new charge on 1 April 1841, becoming the first native to be placed over Europeans. His staff consisted of one chief assistant, four European foremen, 100 European engineers and boiler makers, and about 200 native artificers. It burned many a European heart. The *Bombay Times*, a newspaper with a bias in favour of colonial rulers, did not approve of his appointment. It wrote, “*We doubt the competency of a native, however able or educated, to take charge of such an establishment as the Bombay Steam Factory with a body of Englishmen to be directed, superintended and controlled*”.

But Cursetjee made a success of the job. He visited America in 1849 and selected woodcutting machines to be sent on to Bombay. The manner in which Indians were stereotyped by Americans can be seen in the following memoir by a member of a family he visited in the USA:

*Among the strange foreign visitors of those days, we were somewhat startled one evening by a friend’s bringing a real live Parsee, with a tall calico headdress, to take tea with us. It was rather a revelation to me that a fire worshipper could take tea like ordinary mortals. But he was a harmless lion, and roared very gently, and drank his tea and ate his bread and butter quite like other folks and told us many interesting things about his life in Bombay. I remember we all spoke very distinctly, as if we were talking to a child, and that he answered us in a very low cultivated refined voice, using much better English than we did.*

In February 1851, Cursetjee launched a steamer called *Lonjee Family*. Every part of this ship was indigenously fabricated at Ardaseer Cursetjee’s own foundry located at his residence. He was the first to introduce Bombay to the sewing machine, photography and electroplating.

In 1861, he was appointed Superintending Engineer of the Indus Flotilla Company, and took charge of the Company’s steam branch and workshops at Kotree in Sind. The Flotilla was at that time under the Indian Navy, which was

disbanded in 1863. Consequently, the Flotilla was broken up. Cursetjee resigned his post in 1863 and went to England, settling down at Richmond, where he died on 16 November 1877.

It is surprising that for all his achievements, he remains virtually unknown. Calcutta by then had become the hub for scientific activity and those leading the renaissance knew little about Cursetjee. This is perhaps the reason why India’s first modern engineer never became a role model for his countrymen. The Government of India did bring out a postal stamp to commemorate the memory of this master ship builder.



# Nain Singh Rawat ( 1830 - 1895 )

After establishing their rule in India it was only logical for the British colonialists to eye the booty which lay in the Himalayas and beyond. But it was tough going. The Emperor of China had closed the Tibetan border to foreigners, on pain of death. Several men of the Survey of India made attempts but died, until Thomas G. Montgomerie hit upon a brilliant solution – of sending in Indians, disguised as itinerant lamas, to literally *spy* and map the land. The recruits had to be young, literate, with Tibetan features, knowing the ways of the mountains and not too demanding. Montgomerie selected two cousins – Nain Singh and Mani Singh – for this Himalayan task.

Nain Singh's childhood was spent in dire poverty. With no inheritance and a large family to support he found it difficult to make ends meet. As an adult he borrowed money and tried his hand at trade but failed. Later he became a school teacher in the village of Milam in the Upper Himalayas. Mani Singh was Nain Singh's older cousin. In 1933, Montgomerie put



these cousins through a rigorous grind which later become the standard training for all future Indian surveyors – or 'chain men'. They were trained to walk in a measured fashion, so that no matter what the nature of the terrain, each pace measured a constant distance – 33 inches. To keep track of the number of paces, they were given rosaries, with 100 beads instead of the traditional 108. One complete circuit of the rosary would mean 10,000 paces and measure 5 miles!

Nain Singh's pilgrim outfit had other special modifications. His tea bowl had a false bottom which stored mercury that helped him find the horizon. His walking stick hid a thermometer, which he would dip into tea water just as it came to a boil and thus determine the altitude. The boiling point of water as every school child knows, changes with altitude.

The biggest sacrilege, though, was Nain Singh's prayer wheel. A prayer wheel is a holy object stuffed with scrolls of the Tibetan mantra *Om! Mane Padme Hum!* (Hail! Jewel in the Lotus!). However, inside Nain Singh's divine prayer wheel were hidden his route survey, careful notes that showed altitudes, landmarks, and the distances that he walked. These *barefoot* surveyors were given code names – Nain Singh was the *Chief Pundit* and his cousin, the *Second Pundit*. These codes stuck on; and all later surveyors were called *Pundits*.

In 1865, the two pundits departed on their first mission. While crossing the Tibetan border they had to disguise as pilgrims. Once in Nepal, they separated ways and Nain Singh headed for the Tibetan border near Lhasa. He managed to cross into Tibet by associating with a party of traders. The traders ditched him and stole most of his money. Fortunately, his most precious possessions –



A page from  
Nain Singh  
Rawat's diary.

क डलम हमने गाढम नही सी यवज में रुपय दिये और  
लहा डल और गाढल का भी हिसाब करके पाले और  
सबने आरमी पीछे सवा छः आना लहाडल का और  
उतवाही गो डल का चुकाहिया तब हमें वहाँ में दुइका  
रा भिला ॥  
मोगा क मण्डो से निवाय पंडिकम के इरियाल खूरा  
भ्युं डारी और खम्बा केरु नया व्यापारी जा मोगा  
कि घाटी हाकर सोस के वस्ति थालिंग का जावे है  
उनमे आरमी पीछे दोतमासी योने मसा छः आना  
लहा डल यान पहा लोच का महसल और उनो  
ही गाढल यान अपन जान का महसल और जिस  
में दवागन के हिमावम डल यान महसल लिया गाढ  
ह पंगु खम्बा लोगा को जिन्से मंडल कभी दनागही  
पडता मिफे लहाडल और गाढल जानया पहिल आत  
एकही साल के वास्ते दना पडता फिर कितना ही वरस  
आत कुछे दना नही होतोह और मोगा क मण्डो  
कालाडल और गाढल मुन्नाफे हे सिफे ४४ मपया  
वारिष् का कर सालि आना मुने हे और दवागन क  
हिसाव मंडल का महसल भी दगे है और पन्ने क जव





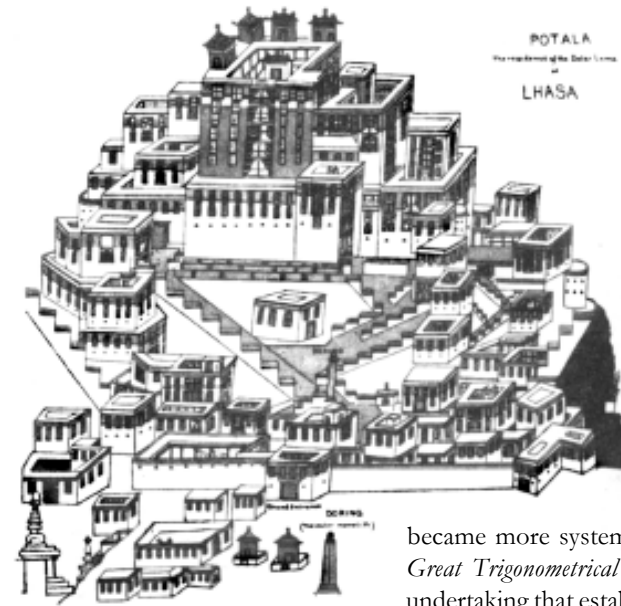
his survey equipment was left behind. It was hidden in a box with a false bottom.

With this primitive apparatus, he spent the entire summer of 1865 journeying to Lhasa, begging for food from the rare caravan that appeared. In January 1866, he finally reached the 'forbidden' city of Lhasa, where he lived like a pilgrim. He stayed in an inn for several weeks, and used the roof of the inn as his observatory at night. By measuring the boiling temperature of water, he calculated the altitude of Lhasa to be 3240 m above sea level. Today with all the modern equipment we know it to be 3540 m! From the angular altitude of stars, he calculated the latitude of Lhasa.

In April, he packed his equipment, and left for India with another caravan of people, who were heading west along the Tsangpo – the major Tibetan River. Finally, one night, he stole away from the caravan and struck north for India, reaching the Survey headquarters at Dehradun on 27 October 1866.

Nain Singh made two more voyages. On his second voyage in 1867, he explored western Tibet and visited the legendary Thok-Jalung gold mines. He noticed that the workers only dug for gold near the surface, because they believed digging deeper was a crime against the Earth and would deprive it of its fertility.

In 1873-75, he travelled from Leh in Kashmir to Lhasa, by a route more northerly than the one along the Tsangpo that he had taken on his first journey. His maps provided the only definitive information on these parts for almost half a century. This last journey had taken its toll on his health, also

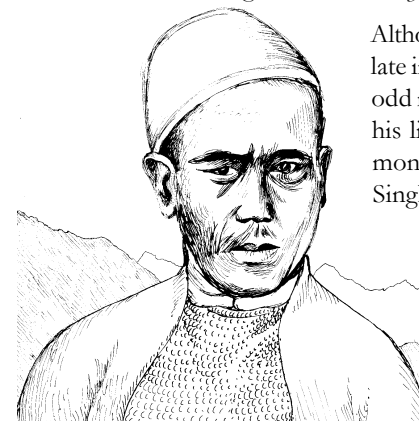


impairing his vision. He continued for a few years to train other Indians in the art of surveying (and spying), and did a highly commendable job of it too.

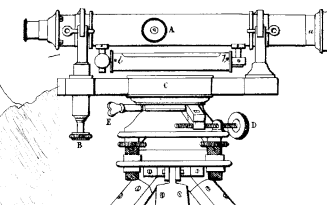
In Dehradun, Nain Singh's route surveys were collated together and slowly accurate maps were prepared. The process

became more systematic with the launch of the *Great Trigonometrical Survey of India* - a massive undertaking that established well-known points of latitude and longitude and then gradually built triangles between the points until a full map of the coast and interior of India was built.

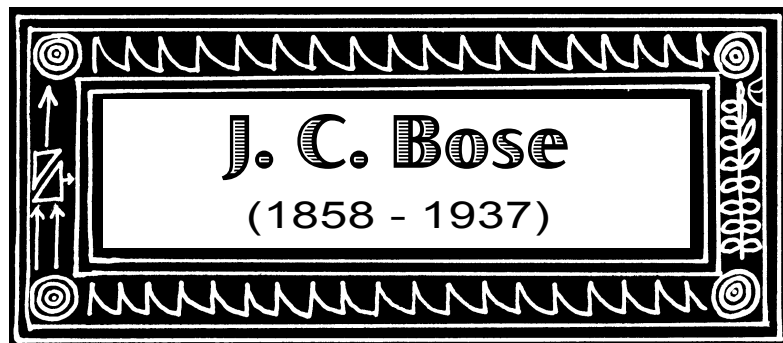
Nain Singh's name and feats soon gained fame. In 1876, his achievements were announced in the *Geographical Magazine*. The awards and recognition soon started flowing in. On his retirement, the Indian Government honoured him with the grant of a village, and 1000 rupees in revenue. Nain Singh was presented with an inscribed gold chronometer by the Royal Geographic Society (RGS) in 1868. This was followed by the award of the Victoria or Patron's Medal of the RGS in 1877 saying, "Here is a man who has added a greater amount of positive knowledge to the map of Asia than any individual of our time." The Society of Geographers of Paris also awarded Nain Singh an inscribed watch. On June 27, 2004, an Indian postage stamp featuring Nain Singh was issued commemorating his role in the *Great Trigonometrical Survey*.



Although Nain Singh got the recognition he deserved late in life, one wonders why he trudged over 16,000 odd miles of the toughest terrain, constantly risking his life, all for a starting salary of rupees twenty a month! Perhaps, in the end it was all worth it - Nain Singh dared and did what no white man could do.



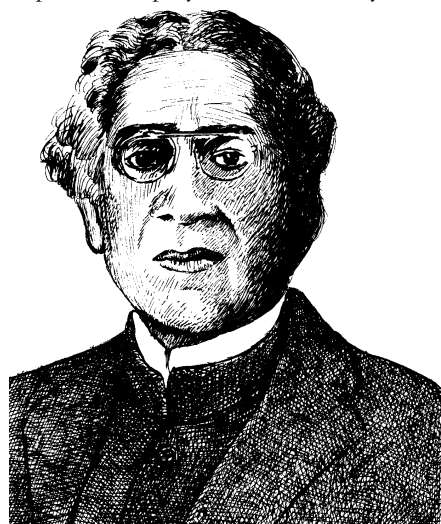




In 1895, Marconi stupefied the world by transmitting a wireless signal and detecting it with a receiver over a mile away. But two years before this Jagadish Chandra Bose of the Presidency College, Calcutta, gave a public demonstration of wireless communication using wireless waves to ring a bell a mile away. Bose made original contributions in two very different fields of research – radio waves and plants. So great was his understanding of the sensitivities of plants that his students jokingly suggested that he could *talk* to plants.

J.C. Bose was born on 30 November 1858 in Mymensingh, currently in Bangladesh. His father, Bhagavan Chandra Bose was a benevolent bureaucrat. He loved the Bengali language and had deep sympathies for the poor. He tried to provide employment to the needy but his efforts failed leaving him deeply

indebted. But his father's idealism and sympathy for the poor inspired Jagadish throughout his life.



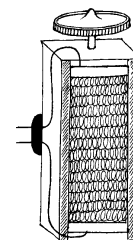
Jagadish went to a Bengali medium school where he mingled with local children of different backgrounds. This rich experience immunised him for life from caste, class and religious prejudices. From the earthy children of the poor he also acquired an abiding love for animals, plants and birds. Later it induced him to study plant behaviour in depth.

In 1875 he joined the St. Xavier's School in Calcutta where he spent all his pocket money on tending plants and pets. He obtained a degree in science from the St. Xavier's College in 1879. Here he met Father Lafont, a superb teacher of Physics. Jagadish wanted to go to England and get into the coveted Indian Civil Service. His father did not like the idea of serving the British, but agreed to Jagadish becoming a medical doctor so that he could later serve the needy.

He went to England in 1880 but soon fell ill. Expert treatment failed to cure him. He suffered from *Kala-azar*. As strong odours of the dissection rooms could aggravate the disease he was advised to give up medical studies. Later he joined Christ's College in Cambridge University for a course in natural science. Here he was taught by the outstanding scientist Lord Rayleigh. Jagadish stuck a life-long friendship with his teacher.

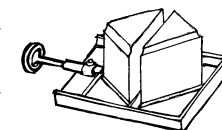
On returning to India in 1885 he was appointed a Professor of Physics at the Presidency College, Calcutta. Here, he was openly discriminated against. An Indian got only two-thirds of what an Englishman was paid for the same job. Bose protested in a novel way. He worked enthusiastically for three long years without salary though his father was deeply indebted. In 1887 he married Abala Bose. But this did not matter. He stuck to his guns and withstood all the hardships. Finally the administration relented and he was paid the full salary, with arrears. This fortune helped him clear his father's debts.

At Presidency College, Bose proved to be a gifted and popular teacher. He found physics exciting and conveyed its magic with experiments and practical demonstrations. Many of his students became famous scientists. Among them was S. N. Bose, the statistical physicist, after whom a family of elementary, subatomic particles, the *Bosons*, is named!



Bose designed this spiral spring receiver to detect short wavelengths of radiation.

His efforts to develop research facilities in Presidency College were repeatedly thwarted by British officials. So finally, Bose set up a laboratory in an abandoned bathroom in the physics department. Here with very rudimentary equipment he commenced serious original research on generation, transmission, refraction, diffraction, polarization and detection of electromagnetic waves. Several familiar microwave components of today – waveguides, lens antennas, polarizers, dielectric lenses and



A double prism attenuator

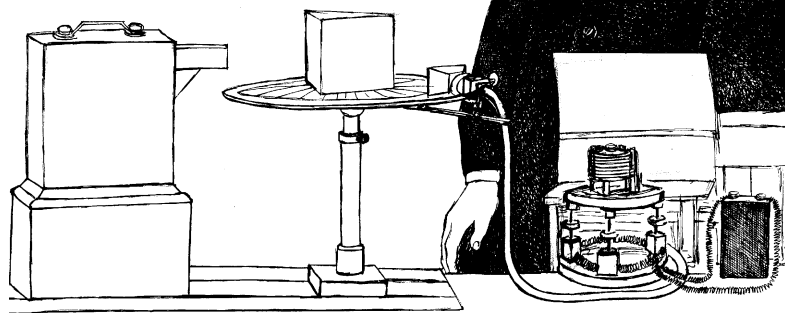
prisms, diffraction gratings – can be found in his experiments. Many were invented by him – including the exotic twisted-jute polarizer! His receivers based on galena (lead ore) crystals were issued patents in 1904. W. H. Brittain, co-inventor of the transistor and Nobel Laureate in 1977 credits Bose with the first use of semi-conducting crystals to detect radio waves. Neville Mott, Nobel Laureate in 1977 for work in solid-state electronics, credited Bose as being at least 60 years ahead of his time, saying that, “*In fact, he had anticipated the existence of p-type and n-type semiconductors.*”



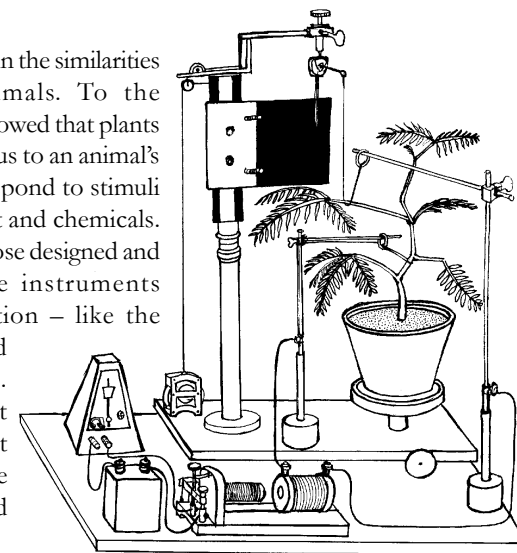
A twisted-jute polarizer

Bose was only interested in the science behind the phenomena and not in patenting it and amassing wealth. His contemporary Marconi on the other hand instantly recognised the commercial potential of *wireless* and exploited it by constructing wireless communication equipment.

Bose went to Europe on a study tour where he met some leading scientists of the world including Lord Kelvin and Professor FitzGerald. Around 1897, Bose's interest began to shift fairly substantially. The receiver (then called *coherer*) which he built to sense radiation showed a *peak* and *low* performance. This intrigued him. The resemblance to human fatigue and revival was uncanny. He concluded that the *coherer* underwent similar cyclic molecular changes during activity, fatigue, rest and renewal. His paper titled *On the general molecular phenomena produced by electricity in living and non-living matter* evoked a fierce reaction. The development of Biophysics and Cybernetics, several decades later, was to show that Bose was on the right track.



Bose next became interested in the similarities between plants and animals. To the astonishment of many, he showed that plants too have something analogous to an animal's nervous system and they respond to stimuli such as electric current, heat and chemicals. Since this subject was new, Bose designed and constructed many of the instruments required for experimentation – like the *Crescograph* which measured the growth rate of plants. With this instrument it became possible to carry out accelerated tests to determine the effects of fertilisers and insecticides on plants.



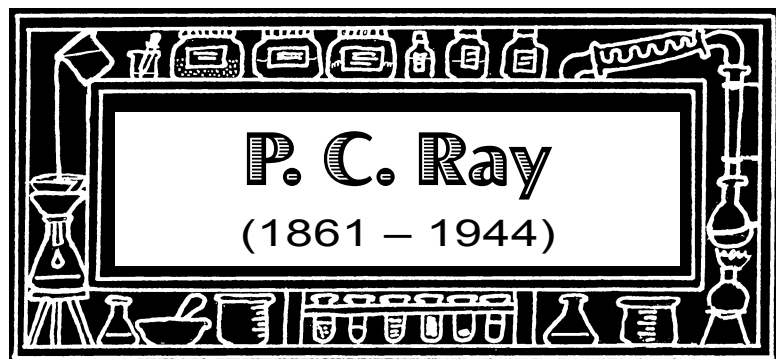
Bose wrote numerous popular articles in Bengali to spread the excitement of science amongst the common people. Bose's latter career coincided with the rise of the freedom movement. His strong national feelings inevitably drew him close to Rabindra Nath Tagore, Prafulla Chandra Ray and Sister Nivedita - the British-born disciple of Swami Vivekananda.

Bose retired from academic service in 1915. Knighthood was conferred on him and he became Sir Jagadish Chandra Bose in 1917. That very year on his birthday, Bose established the Bose Research Institute – dedicated to interdisciplinary research. Tagore composed the inaugural song for the institute. In 1920 Bose was elected a Fellow of the Royal Society.



Bose was a patriot and a cultural nationalist, proud of the ancient heritage of his land. He realised that colonialism was sapping the self-respect of Indians. He proved to the West that Indians too could do world class scientific research.

Jagadish Chandra Bose passed away on 23 November 1937, a few days before completing his eightieth year. He left behind a rich legacy, for succeeding generations of Indian scientists to carry forward.



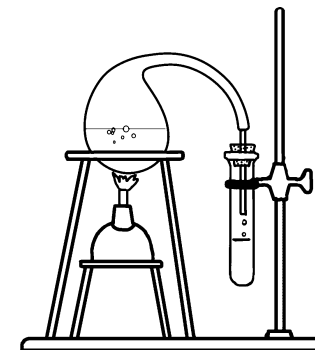
*"It is difficult to believe that the man in simple Indian dress wearing simple manner could possibly be the great scientist and professor."*

*- Gandhi*

The decade 1860-69 saw the birth of some of the most outstanding Indians – Rabindra Nath Tagore, Motilal Nehru, Madan Mohan Malaviya, Mohandas Karamchand Gandhi, Vivekananda and Prafulla Chandra Ray.

Prafulla Chandra was born on August 2, 1861 in a village which is now in the Khulna District of Bangladesh. After his initial schooling in the village his erudite father Harish Chandra shifted to Calcutta to give his children a better education. The young Prafulla was deeply influenced by social reformers of the Brahmo Samaj. He studied at the Presidency College since his own college – the Metropolitan College (set up by Ishwar Chandra Vidyasagar) did not have the requisite facilities. During his days chemistry was a compulsory subject in the Fine Arts (FA) course. In 1882, under heavy odds and with sheer brilliance he won the Gilchrist Scholarship and went to study science at the

Edinburgh University. Here the famous chemist A. C. Brown became his favourite teacher and guide. He finished DSc in 1887. Later he won the Hope Prize and became the Vice President of the University Chemical Society. His stay in Edinburgh made him passionately fond of chemistry.



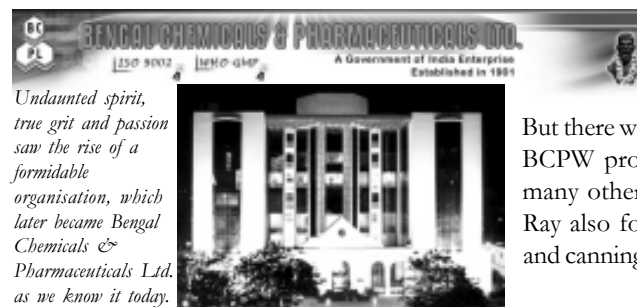
On returning to India in 1888 he found it difficult to get a University job as they were reserved for white men. Later, he got one and spent the next 27 years teaching at the Presidency College. Ray became well known as a very good teacher and enlivened his classes by actual demonstrations. Among his students were two future stalwarts, Meghnad Saha and Satyendra Nath Bose. Many bright students of that time – such as Nil Ratan Ghosh and J. C. Ghosh were attracted to him and this is how the first Indian School of Chemistry was born. Slowly, its fame and contributions spread far and wide.

Jagadish Chandra Bose – famous for *radio waves* was three years senior to Ray in College. These two friends were the flag bearers of Indian science at the threshold of the new century.

Ray had witnessed the synergy between science and industry during his stay in England. The British colonists were interested in exploiting India's mineral wealth but not in developing its industries. This task fell on Ray. He found time and money to research on pharmaceuticals, mineral acids and a host of other products. In 1901, this resulted in the establishment of Bengal Chemical and Pharmaceutical Works (which still exists, now called BCPL). But the going was tough. His attempts to produce citric acid from lemon did not succeed. He also failed to produce sulphuric acid commercially. But, finally he managed to produce caustic soda from cattle bones. On several occasions he had to convince

the police and his neighbours that he was not using human bones!

But there were huge spin offs. As BCPW prospered it stimulated many others to start industries. Ray also founded pottery, soap and canning factories.



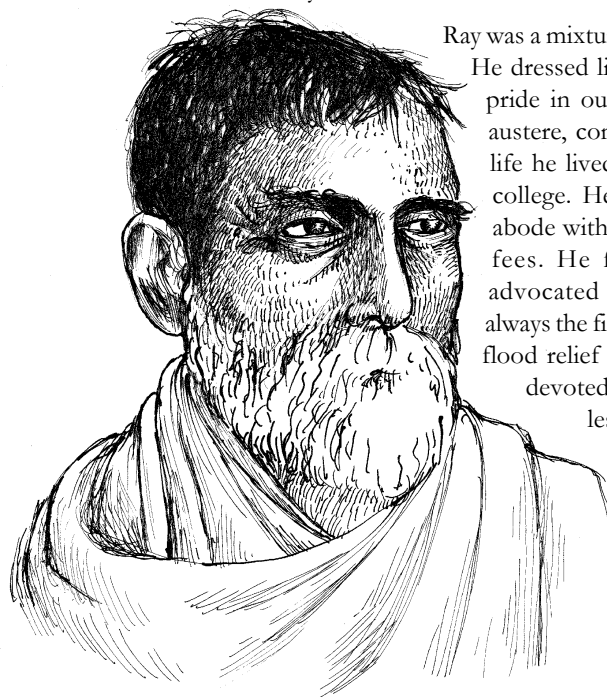
*Undaunted spirit, true grit and passion saw the rise of a formidable organisation, which later became Bengal Chemicals & Pharmaceuticals Ltd. as we know it today.*

Ray's research encompassed a wide field. Initially, he took up the issue of food adulteration. While searching for the missing elements in the Periodic Table he discovered mercurous nitrate. For several years he studied this salt and its derivatives. He published over a hundred research papers.

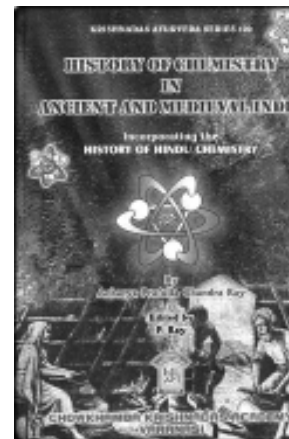
Ray was an ardent advocate of the use of the mother tongue as a medium of instruction in schools and colleges. In recognition of his contribution towards the advancement of Bengali, he was elected the General President of the Bangiya Sahitya Parishad (1931-34). Ray was a voracious reader of literature and history. He was fluent in half a dozen languages. He once claimed that he 'became a chemist almost by mistake.'

Ray was an ardent scholar and was determined to bring out the scientific achievements of ancient Indians, possibly to evoke the pride of his countrymen in their heritage. He wrote *The History of Hindu Chemistry* in two volumes. He wrote his autobiography in two volumes - *Life and Experiences of a Bengali Chemist*.

Ray was a living example of what a focussed human being could do with his time and talents. He retired from the Presidency College in 1916. For the next two decades, at the request of Sir Asutosh Mookherjee he worked as Palit Professor of Chemistry at the newly found College of Science, Calcutta University. Here his research school made important contributions to several areas of chemistry.



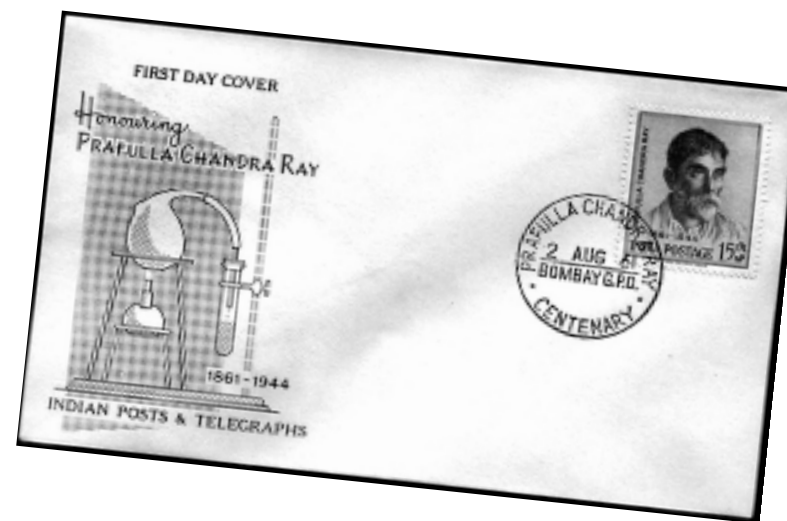
Ray was a mixture of tradition and modernity. He dressed like an Indian and had a deep pride in our heritage. His life style was austere, comparable to Gandhi's. All his life he lived in a single room above the college. He happily shared his humble abode with poor students and paid their fees. He fought untouchability and advocated widow remarriage. He was always the first to volunteer for famine and flood relief work. He never married and devoted his life to the welfare of the less fortunate. His affectionate pupils bestowed on him the title of *Acharya*.

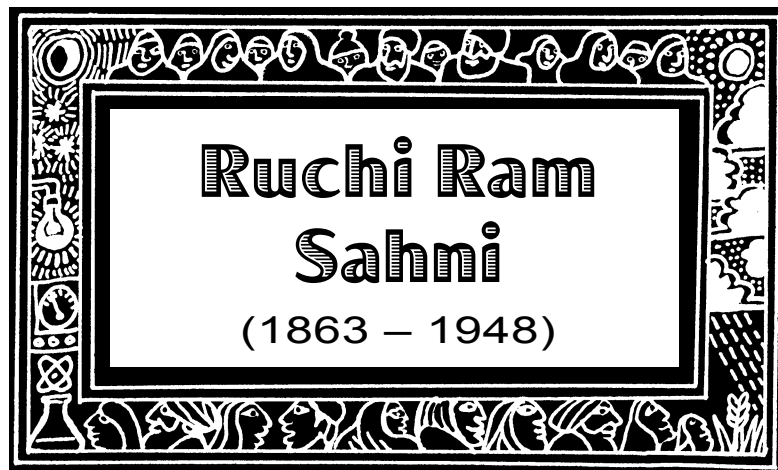


He was knighted in 1919 and in 1934 became an Honorary Fellow of the London Chemical Society. He was showered with honours by several universities. The Indian Chemical Society born in 1924 chose him their Founder President.

C. V. Raman worked as a Palit Professor of Physics in the same Institute with P. C. Ray. Ray adored the young Raman about whom he said, much before he won the Nobel Prize, "If this temple of science produced only one Raman and nothing else, it will have amply justified the high expectations formed by its Founder."

By the time of his death on 16 June 1944 Prafulla Chandra Ray had seen his country and countrymen advance far beyond what he had known in his youth. Some of his dreams came true but the biggest of all - the country's freedom, he was not destined to see. But he had trained and inspired a whole generation of chemists who were to carry on his work in free India. They never forgot their debt to him and always referred to him as the *Father of Indian Chemistry*. In paying homage, the July 1944 issue of *Nature* magazine wrote, "Sir Prafulla was more than anyone else, responsible for the great development of scientific research in India during the past fifty years...."

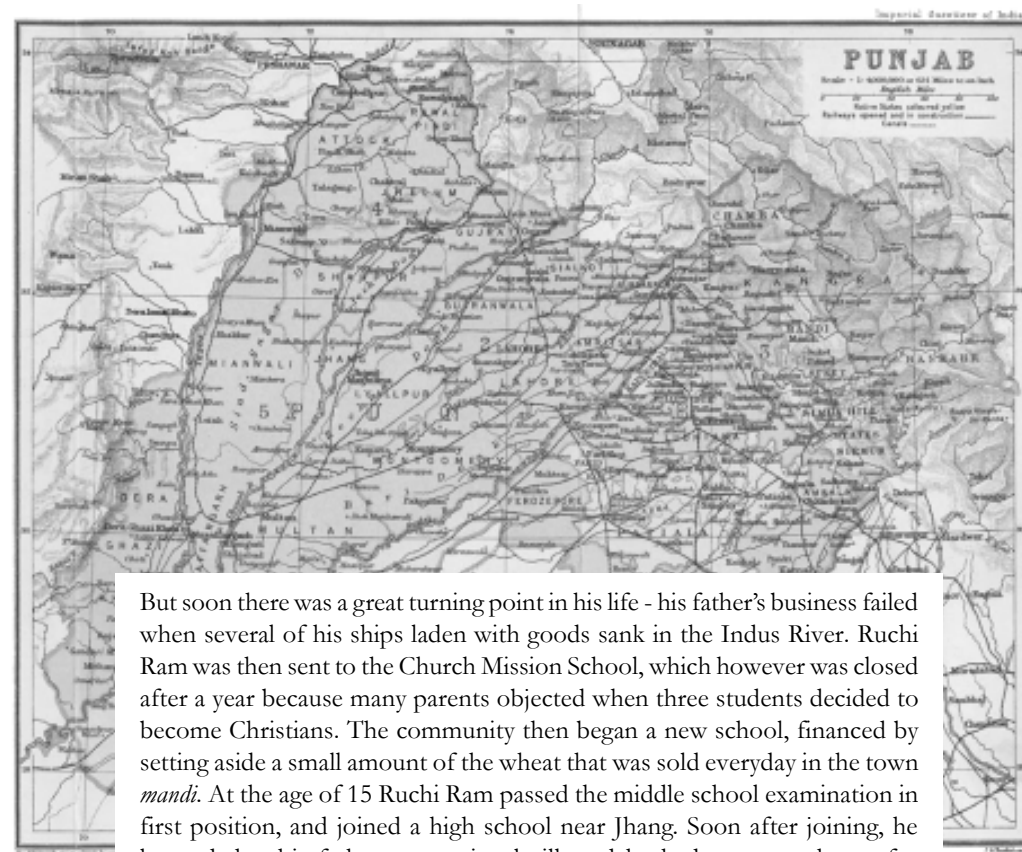
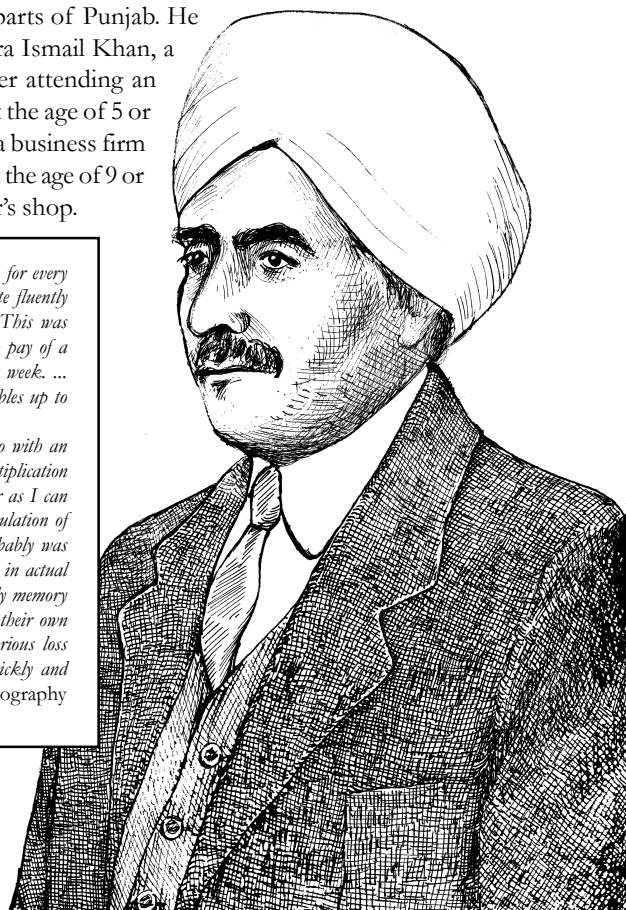




Ruchi Ram Sahni was a pioneer educationist who popularised and spread the knowledge of science in remote parts of Punjab. He was born on April 5, 1863 in Dera Ismail Khan, a small town now in Pakistan. After attending an informal school for a short time at the age of 5 or 6, he was sent to a small shop and a business firm for his practical education. Then, at the age of 9 or 10, he began working in his father's shop.

*"My father paid the Pandahji four annas in cash for every pabara (multiplication table) that I learnt to recite fluently and without hesitation or halting to my father. This was in addition to the usual fee which all boys had to pay of a certain quantity of atta, and a piece of gur once a week. ... When I left the Pandah I knew multiplication tables up to  $20 \times 35$ , and also the fractional tables. ...*

*After leaving the Pandah, I spent a month or two with an ordinary shop-keeper - where I had to apply the multiplication table and the little arithmetic I had learnt. So far as I can remember, I had not much difficulty with the calculation of prices. The object of putting me to this work probably was to make me realise the value of what I had learnt in actual day to day transactions. The tables were not merely memory exercises - they had great practical application of their own and a mistake in their application may mean serious loss in business. The calculations had to be made quickly and correctly." - from Ruchi Ram Sahni's autobiography*



But soon there was a great turning point in his life - his father's business failed when several of his ships laden with goods sank in the Indus River. Ruchi Ram was then sent to the Church Mission School, which however was closed after a year because many parents objected when three students decided to become Christians. The community then began a new school, financed by setting aside a small amount of the wheat that was sold everyday in the town *mandi*. At the age of 15 Ruchi Ram passed the middle school examination in first position, and joined a high school near Jhang. Soon after joining, he learned that his father was seriously ill, and he had to return home for sometime. It was an arduous journey of 250 km each way, by cart, boat, and camel - or to save money, by foot. In 1879 his father died, leaving the family in dire straits. Ruchi Ram however decided to continue his studies. He passed BA from the Government College, Lahore, in 1884, securing the top position in Punjab University. Ruchi Ram was a great debater and took part in many extra-curricular activities.

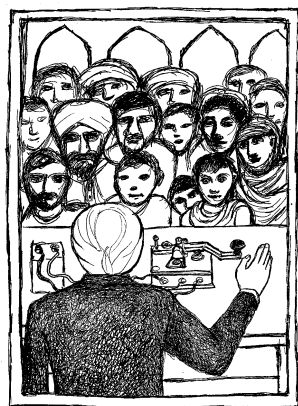
Due to economic necessity Ruchi Ram took up a job with the Meteorology Department at Calcutta. His inspiring teacher Professor Oman advised him to 'earn and learn' and complete his master's degree from the famous Presidency College. In Calcutta Ruchi Ram got deeply interested in the Brahmo Samaj and interacted closely with scientists and social reformers like Asutosh Bose, P.C. Ray and J.C. Bose. Later he was transferred to Shimla - the Headquarters of the Meteorology Department where he prepared 'daily' and 'monthly' weather reports. He made a remarkable forecast of a storm in the Bay of Bengal thus saving many ships from destruction by sending them a timely warning.

In 1887, Sahni joined as Assistant Professor of Science in Government College, Lahore and later became in-charge of the Department of Chemistry. He enlivened his lectures by experimental demonstrations and this made him a very popular teacher. The head of the department, a British Professor, felt jealous of Sahni's popularity and made life hell for him. In the end the self-respecting Sahni resigned and started a chemical factory which did not do well. In 1914, Sahni left for Europe to carry out research in the emerging field of radioactivity with Dr. Fajans in Germany. But before he could settle down World War I broke out and he had to quickly escape to England.

In England, Sahni was fortunate to work with the world renowned nuclear physicist, Lord Rutherford and collaborate with Niels Bohr. He published two research papers on scattering of alpha particles in photographic emulsion under joint authorship with Prof. Rutherford. He soon returned to India as the situation became critical in war-ravaged England.

After returning, Sahni joined the Punjab Science Institute (PSI) as its joint secretary. The PSI was set up by Prof. Oman with the objective of spreading scientific knowledge throughout the Punjab by means of popular science lectures with lantern slides and actual demonstrations. Punjab of those days stretched from Delhi to Peshawar. While in Shimla, Sahni had already given a series of popular science lectures on *Weather Forecasting*. These lectures became a great hit with common people. Village and urban folk, labourers and shopkeepers flocked to them, often buying a two-anna 'ticket' to witness the performance! This fee helped offset some of the travel costs. The themes of Sahni's popular lectures covered common, everyday subjects such as *Soap-making*, *The water Laboris drank before 1880*, *Pure and impure air*, *Electricity in the service of man*, *Electroplating*, *Glass-making*, *The Punjab and its rivers* (illustrated by a large relief map made in clay) and so on.

These popular science lectures were organized in mofussil towns and villages during festivals and fairs to attract huge crowds. To make the lectures attractive for villagers, they were projected theatrically. These lectures created a tremendous interest in the study of science. Sahni was always in demand and delivered over 500 popular science lectures!



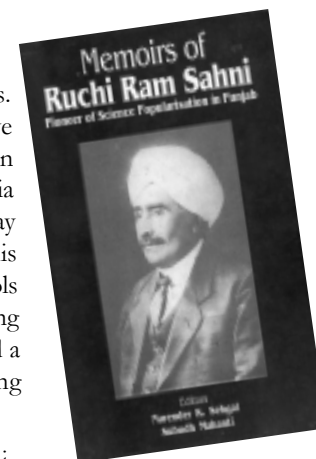
Sahni realised that schools and colleges had no labs. All science equipment was imported at a prohibitive cost. He set up a workshop in 1888, in his own house to manufacture high-quality, made-in-India science apparatus. For this he engaged a skilled railway technician, Allah Bakhsh, on a part-time basis. This science equipment was often gifted or sold to schools at cost price to promote experimental skills among students and teachers. The workshop later added a lathe and became renowned for manufacturing scientific equipment of high precision.

In 1893, Prof Sahni was invited by Sri Namjoshi - a well known social worker to attend a conference in Poona. Sahni took this wonderful opportunity to display all his scientific apparatus. A three member committee was appointed to examine and give its recommendations on the equipment. *The committee did not believe that the apparatus could have been made at Lahore or anywhere else in India.* They felt the instruments were made in England and all the PSI workshop did was to repaint them with Indian varnish to give an indigenous look! They simply couldn't believe that such precision instruments could be produced in India at half the cost.

In 1906, at a Calcutta Industrial Exhibition, these scientific exhibits were awarded the gold medal by a committee which had Prof. J.C. Bose as one of the judges.

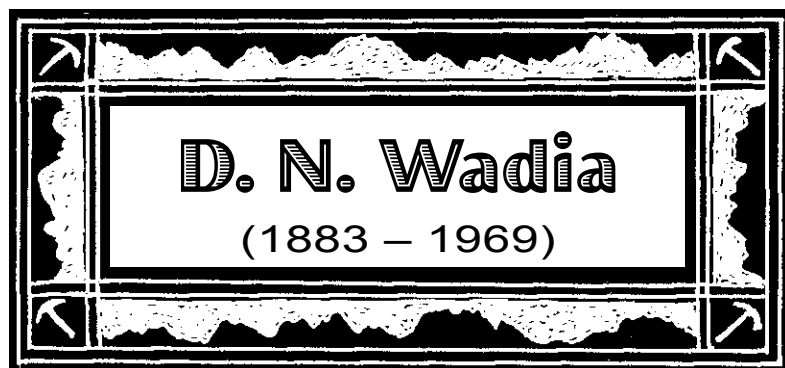
Sahni retired as a senior professor of chemistry from the Government College, Lahore, in 1918. Later he came in contact with Mahatma Gandhi and fully immersed himself in the freedom struggle. He was a founder Trustee of *The Tribune*, which started its publication from Lahore. He was also a founder member of the Dyal Singh College and Library.

Professor Sahni had five sons and three daughters. His son Birbal Sahni – an eminent palaeobotanist was the first Indian botanist to win the FRS. In his autobiography *Self Revelations of an Octogenarian* Ruchi Ram Sahni vividly recounts his life's struggles. His grandson Prof. Ashok Sahni – an eminent geologist retired from the Geology Department of Punjab University, Chandigarh. His granddaughter Prof. Mohini Mullick inspired generations of students at IIT / Kanpur with her deep insights in *Symbolic Logic*. Prof. Ruchi Ram Sahni who ushered the scientific renaissance in Punjab died at the age of 87 on June 3, 1948, in Bombay.



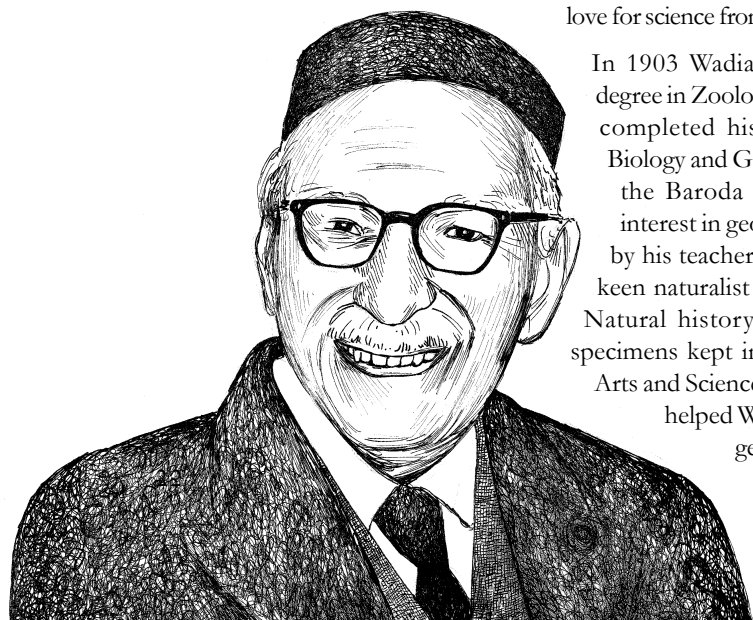
*Memoirs of Ruchi Ram Sahni have been recently published by Vigyan Prasar.*





Darashaw Noshewan Wadia was a pioneering Indian geologist whose work laid the foundation for geological investigations in India. His major observations and interpretations in the early days of Indian geology still hold good.

Wadia was born on October 23, 1883 at Surat. He came from the same family as Ardaseer Cursetjee - the naval architect and the first Indian to be elected as a Fellow of the Royal Society (FRS). Wadia's father was a station master posted to a small railway station. As there were no good schools there, Wadia stayed with his grandmother and studied in Surat. Initially he went to a Gujarati school and later to the Sir J. J. English School. When he was 11 years old his family shifted to Baroda where he imbibed a rational outlook and a strong love for science from his elder brother.



In 1903 Wadia obtained a BSc degree in Zoology and Botany. He completed his MSc degree in Biology and Geology in 1906. At the Baroda College, Wadia's interest in geology was aroused by his teacher A. M. Masani - a keen naturalist and Professor of Natural history. The geological specimens kept in the Museum of Arts and Science at Baroda greatly helped Wadia to pursue his geological studies.



*Nanga Parbat*

In 1907 Wadia joined the Prince of Wales College in Jammu as a Professor of Geology where he served for 14 years. Later it was renamed as Mahatma Gandhi College and is now affiliated to the Jammu University. Besides geology, Wadia also taught English, a testimony of his command over the language. During the Jammu stay Wadia spent his vacations trekking the Himalayas and familiarized himself with its geology. He collected minerals, rocks and fossils which he used extensively to make the teaching of geology interesting.

He took students on adventure treks and investigative field trips in the Siwalik Hills of the Jammu region. His keen eye for observations helped him identify many significant artefacts. It was in one of these trips that he discovered a 3 metre long fossil tusk of an elephantine mammal *Stegodon ganesa*, a finding of crucial importance. He climbed peak after peak in the Himalayas to better understand its geology and structure. Wadia explained the abnormal sequence of rock formations of varied ages in the North-Western Himalayas and also the unique knee-bend of the mountain chains around the Nanga Parbat. Deeply devoted to the study of the Himalayas he was responsible for the establishment of the Institute of Himalayan Geology in Dehradun and became

its founder director (1968-69). The Institute was later renamed as the Wadia Institute of Himalayan Geology in Wadia's memory. He was intimately associated with the establishment and functioning of the National Geophysical Research Institute at Hyderabad and the National Institute of Oceanography in Panaji, Goa.



In 1921 Wadia left the Prince of Wales College, and joined the Geological Survey of India (GSI) as an Assistant Superintendent. He was just 38 years old and the first Indian without any European degree to be appointed in the GSI. Working in the GSI provided him ample opportunities for carrying out further geological investigations in the north-western Himalayas where he made pioneering contributions. R. D. West wrote: *"Wherever Wadia travelled in the Himalayas he was successful in throwing significant light on problems of stratigraphy and tectonics which had hitherto remained uninvestigated or unexplored."*

Wadia authored about one hundred original research papers, monographs on various geological topics. In 1928 he discovered a very well preserved skull of *Actinodon* which led to the fixing of the age of an important geological rock formation in the Kashmir Himalayas. He also discovered the existence of vast reservoirs of sulphide ores of copper, nickel, lead and zinc.

While working in the Geological Survey of India, Wadia spent his study leave (1926-1927) at the British Museum, where he worked on the vertebrate fossils collected from Kashmir. During this period he also visited geological institutions in Germany, Austria and Czechoslovakia.

Wadia noted the neglect of soil science in India and showed the way for its rectification by his own writings. In 1935 Wadia, jointly with M. S. Krishnan and P. N. Mukherjee, published the first *Soil Map of India*. This was published by the Geological Survey of India and paved the way for later soil maps.

After his retirement from the Geological Survey of India in 1938 he joined the Government of Sri Lanka (then Ceylon) as a Mineralogist. His studies included accurate geological maps of the island and geological investigations concerning water supply, dam-sites and other engineering projects. Wadia produced the first geological sketch map of Colombo.

Wadia was the founder director of the Indian Bureau of Mines (1947) and the Atomic Minerals Division (1949-69). He was an ardent advocate of a national policy for the search, utilization and conservation of mineral resources including

gas, oil and water. He was an avid reader and wrote the first authoritative textbook on Indian geology. Wadia's book, which proved to be a classic on the subject, reached its sixth edition in 1966. Commenting on the book, K. S. Valdyia wrote: *"The erudite book he wrote—The Geology of India—published in 1919 by the Macmillan, London, distils his vast and intimate knowledge of the geology of the entire Indian subcontinent, embracing Pakistan, India, Bangladesh, Myanmar and Sri Lanka. This classical work, which had six editions, made him not only a celebrity but also a guru of countless generations of students of geology all over the world."* Wadia was extremely energetic and hardworking and lived a simple life.

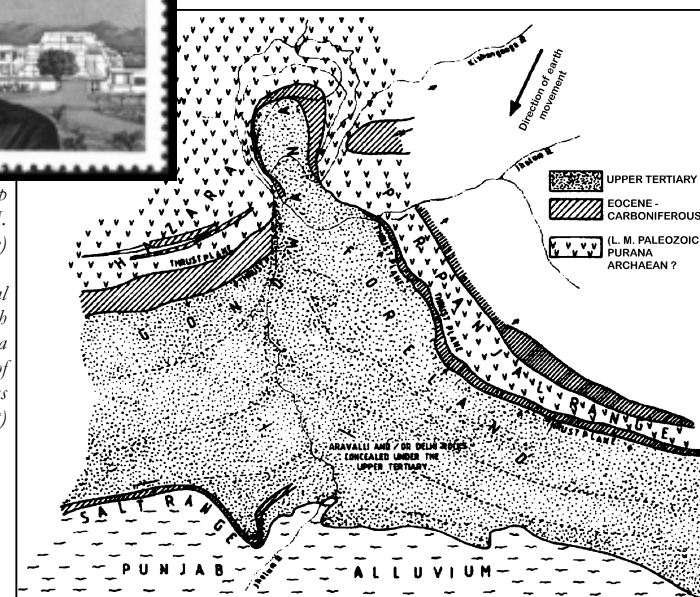
In 1945 Wadia was appointed the Geological Advisor to the national government of Jawaharlal Nehru. He initiated and formulated a mineral policy for the country. In 1963 the Government of India made him the first National Professor in geology. The government of India honoured him with the award of Padma Bhushan (1958). In 1957 Wadia was elected a Fellow of the Royal Society of London. He was showered with numerous national and international awards and honorary doctorates from various universities.

Wadia wrote some amazing popular science essays – *The Story of a Stone* being a classic. In it he succeeds in giving us several fundamental lessons in geology, all the while keeping us absorbed in its autobiography. After reading it one feels there are true *sermons in stones*. The doyen of Indian geology died on June 15, 1969 at the age of 86.

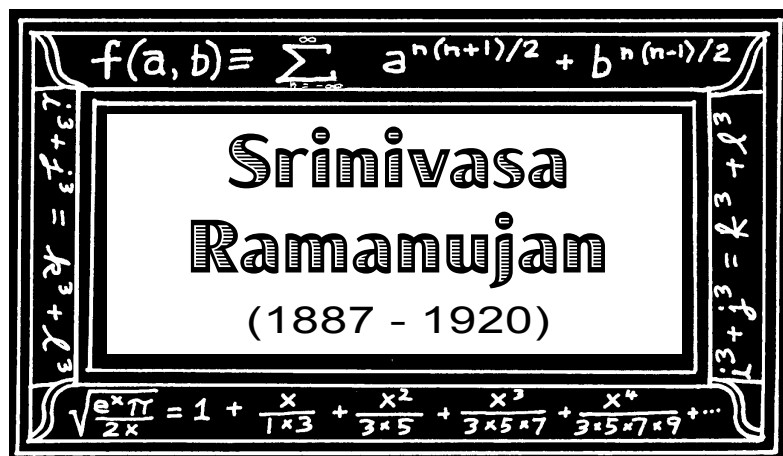


A postal stamp honouring D.N. Wadia (above)

A geological structural sketch of the Nanga Parbat region of the Himalayas (right)





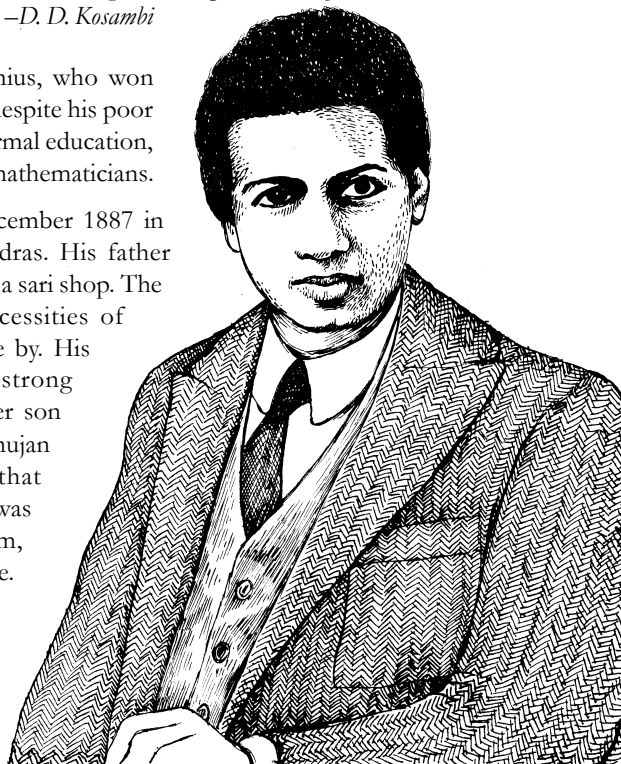


*"Our country has produced only one mathematician of the first rank after Bhaskaracharya eight hundred years ago. This was Ramanujan and he was unable to pass even the first year of college. India gave him birth, starvation, tuberculosis, and a premature death. It is to the everlasting credit of the English mathematician Hardy that he recognized the merit of one who was considered half made by the Indians, had him brought in England, trained him, and brought out his splendid ability."*

—D. D. Kosambi

The life story of this Indian genius, who won worldwide fame in mathematics despite his poor family background and lack of formal education, is legendary among professional mathematicians.

Ramanujan was born on 22 December 1887 in Erode, about 400 km from Madras. His father Srinivasan was a low-paid clerk in a sari shop. The family was poor. Even the necessities of everyday life were hard to come by. His mother, Komalathammal was strong willed and determined to see her son come up in life. From her Ramanujan imbibed the deep spirituality that characterised his adult life. He was raised in nearby Kumbhakonam, which was his mother's native place.

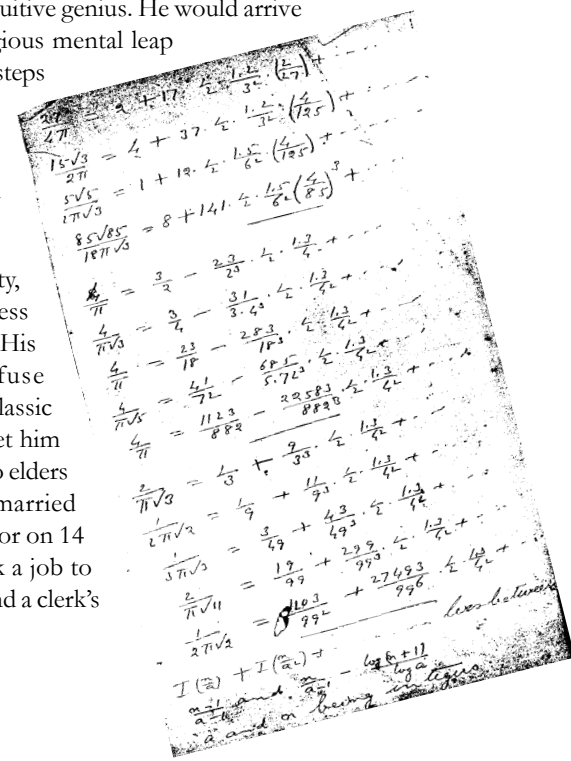


His mathematical talent began manifesting itself when he was about ten. He could learn the subject effortlessly by himself and even clear the doubts of students much senior to him. In high school, he studied G. S. Carr's *A Synopsis of Elementary Results in Pure Mathematics*. This book later became famous in the mathematical world because it influenced Ramanujan's unique style of jotting down his results, without explaining his methods. He later attended college hoping to pass the exam required to enter the University of Madras. But he was so absorbed in mathematics that he neglected other subjects and failed the exam. He never earned a bachelor's degree.

The next few years were really miserable for Ramanujan. He tried his hand at giving private tuitions. But he did not even succeed in this. While teaching mathematics he would jump several steps and lapse into higher reaches of the subject. The students found him utterly incomprehensible, though they respected him for his obvious genius. This phenomenon plagued Ramanujan all his life. His originality was beyond the pale of most mathematicians. They always wondered whether he was a genius or just a clever poser!

The famous *Notebooks of Ramanujan* had their origin in this period. He had a particular fascination for numbers. Every rational number was his friend. He did not realise the need for rigorous proof, which was the forte of Western mathematics. His genius was an intuitive genius. He would arrive at the final solution with a prodigious mental leap but would not care to set down the steps to the solution. Two generations of mathematicians have pored over his note books, trying to prove his formulations. Even now they have not been fully worked out.

Ramanujan was by now over twenty, and in the eyes of his elders 'shiftless and lost in a world of his own'. His mother resolved to infuse "responsibility" into him by the classic Indian method - she decided to get him married! Since implicit obedience to elders was then the rule, Ramanujan married Janaki Ammal, eleven year his junior on 14 July 1909. This forced him to seek a job to support his family. In 1912, he found a clerk's



position in the accounts section of the Madras Port Trust. Its chief accountant Narayana Rau, was a mathematician. Both he and Sir Francis Spring, the chairman of the Port Trust, took a keen interest in Ramanujan's mathematical talents.

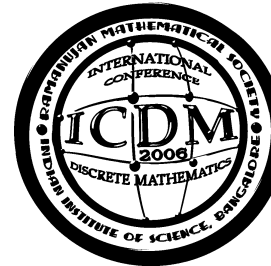
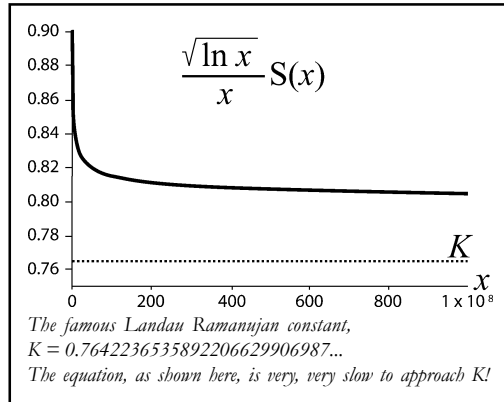
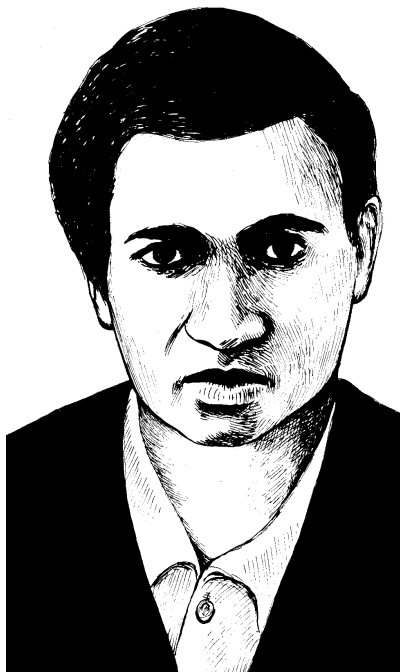
Ramanujan sent his work to mathematicians in England for evaluation.

But given his lack of formal education, he was not taken seriously and his letters went largely ignored. In 1913, however, Ramanujan sent an intriguing letter to G.H. Hardy, an eminent mathematics professor at Trinity College, Cambridge. In this letter, he listed about 120 mathematical theorems without

showing the details of the proofs.

*"I had never seen anything like them before," Hardy wrote later. "A single look at them was enough to show that they could be written by a mathematician of the highest class. They must be true because, if they were not true, no one would have the imagination to invent them". Hardy was deeply impressed and was instrumental in bringing Ramanujan to Cambridge for further study.*

Initially Ramanujan's deeply religious family objected to his crossing the seven seas and going abroad. According to some, his mother had a dream in which the Goddess Namagiri commanded her not to stand in the way of her son's goals. Thereafter, the family relented and Ramanujan arrived at Cambridge in 1914. His research



flourished and he published many exciting new results on topics such as the number theory, infinite series and indefinite integrals. One of the most spectacular results in mathematics is the Hardy-Ramanujan formula derived in 1917 for the number of partitions of an integer. A striking characteristic of Ramanujan's work is the mysterious mix of symbols and formulas. He believed that the Goddess Namagiri appeared in his dreams to guide and inspire his work.

Ramanujan was awarded a Bachelor of Science degree by Cambridge in 1916 and was made a Fellow of the Royal Society (FRS) in 1919. Being a strict vegetarian he would cook his own food. Perhaps due to the intense pressure of work and lack of a proper diet, he contracted tuberculosis in England and was admitted to a nursing home. Hardy visited him there and remarked, *"I thought the number of my Taxicab was 1729, it seemed to me a rather dull number."* Ramanujan replied: *"No Hardy! It is a very interesting number. It is the smallest number expressible as the sum of two cubes in two different ways."* Nowadays, this is referred to as *The Taxicab Problem* and integer solutions to the equation

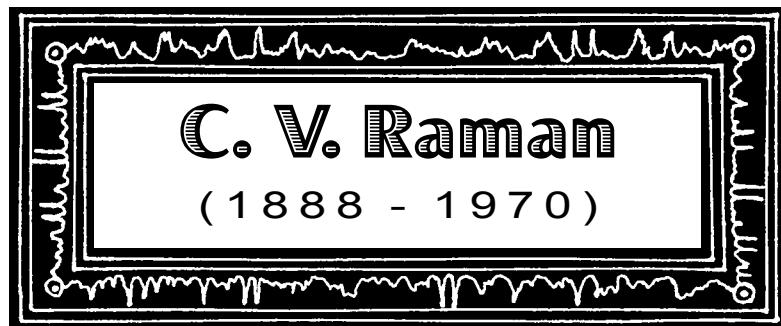
$$i^3 + j^3 = k^3 + l^3$$

are called Ramanujan numbers. Many eminent mathematicians have devoted their lives trying to decipher Ramanujan's work from his notebooks.

Ramanujan returned to India in 1919 and died in Kumbhakonam the next year. He was richly lauded for his achievements. In 1962, the Indian Government issued a postage stamp commemorating his 75th birth anniversary.



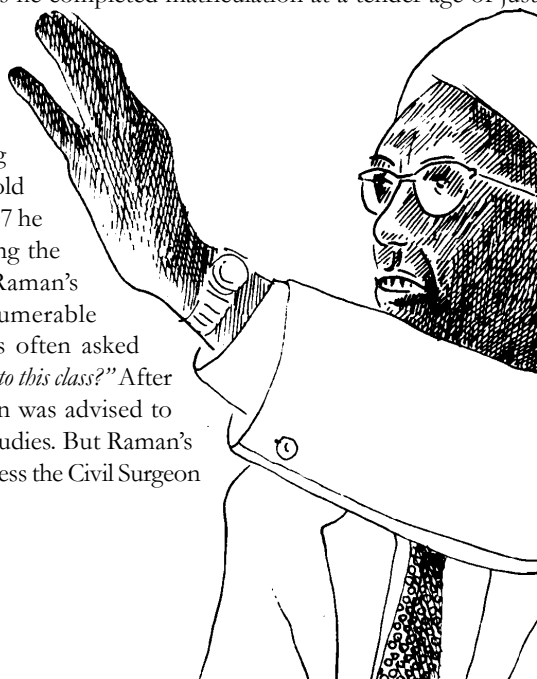
A prize for young mathematicians from developing countries has been created in the name of Ramanujan by the International Centre for Theoretical Physics (ICTP), in cooperation with the International Mathematical Union, who nominates members of the prize committee.



Even as science labs run amuck with funds and sophisticated gadgetry we must not forget that the most expensive and precious piece of equipment is still the human mind! No one symbolized it better than Sir C. V. Raman – the only Indian scientist to have won the Nobel Prize for scientific work done in India. The equipment he used was very rudimentary costing less than Rs 200!

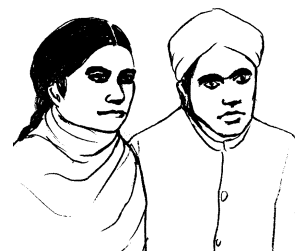
This remarkable scientist was born on 7 November 1888 near Tiruchirapalli, Tamil Nadu. His father was a lecturer of physics and maths. Raman was exposed to books on a variety of subjects' right from childhood. He also imbibed from his father a love for music - on the nature of which he later did considerable research.

Raman had his early schooling in Vishakhapatnam. There being no age restriction in those days he completed matriculation at a tender age of just eleven! Raman entered Presidency College, Madras, in 1902, and in 1904 gained his BA winning the first place and the gold medal in physics. In 1907 he gained his MA obtaining the highest distinctions. Raman's small built posed innumerable problems. His teachers often asked him, "Do you really belong to this class?" After finishing college Raman was advised to go abroad for higher studies. But Raman's puny figure did not impress the Civil Surgeon



in Madras who felt that Raman would not be able to withstand the harsh English climate. Raman was eternally grateful to that surgeon for making him stay on in India!

What did Raman do after an MA in Physics? In those days there were few openings in science and Raman had no choice but to become a civil servant in the Finance Department in Calcutta!



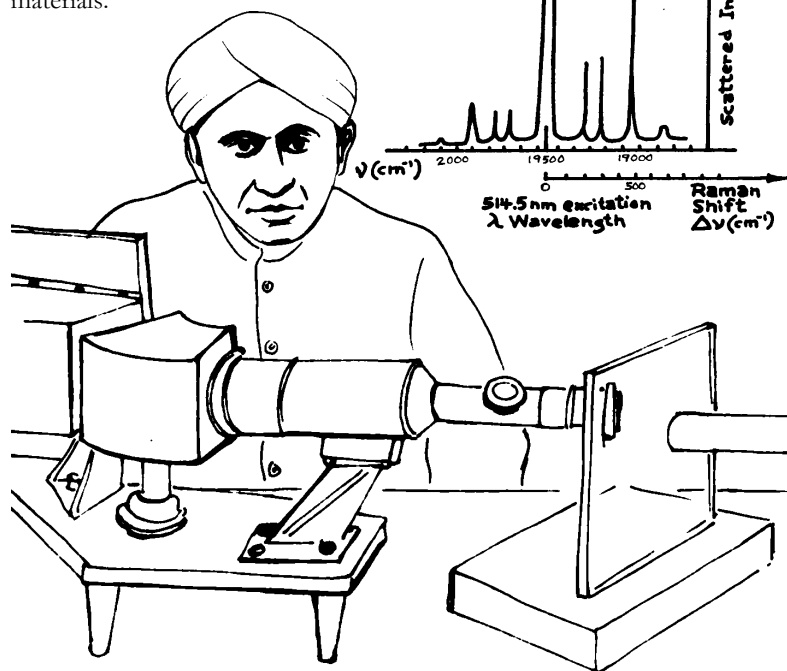
His marriage, like his whole life ahead, was full of drama. While visiting his relatives at their house, he chanced upon young Lokasundari, just 13, and was immediately attracted to her. In a revolutionary move he arranged his own marriage. Lokasundari was singing a Carnatic composition, *Rama Ni Samanam Evaro* (Rama, who is your equal?), when he first saw her!

Though he joined the Finance Department, his interest in Physics did not wane. He conducted experiments in his makeshift home laboratory. As the story goes, one evening while returning from work, he spotted the signboard *Indian Association for the Cultivation of Science IACS* at Bowbazar. Legend has it that he jumped out of a moving tram and rushed to the IACS where he was welcomed by Amritlal Sircar, whose father Mahendralal Sircar had founded this institute in 1876 to promote Indian science. Raman started working in the laboratory after office hours. Soon he started churning out high quality scientific papers which attracted the attention of experts.

In 1917, Sir Asutosh Mookerjee, the Vice-Chancellor of Calcutta University offered Raman the Taraknath Palit Chair of Physics at the University. Raman was delighted. Bidding bye-bye to balance sheets he was at last free to pursue what he loved most.

In 1921 Raman sailed abroad for a conference. This sea voyage had momentous consequences for physics. He was fascinated by the blue waters of the ocean. Why did the sea look blue? Did the ocean reflect the blue sky? Could something else be the cause? Raman felt intuitively that it had something to do with the interaction between water and sunlight. So, while his fellow passengers played cards and bingo, Raman conducted experiments with a pocket spectrometer and churned out a paper on the scattering of light in different mediums.

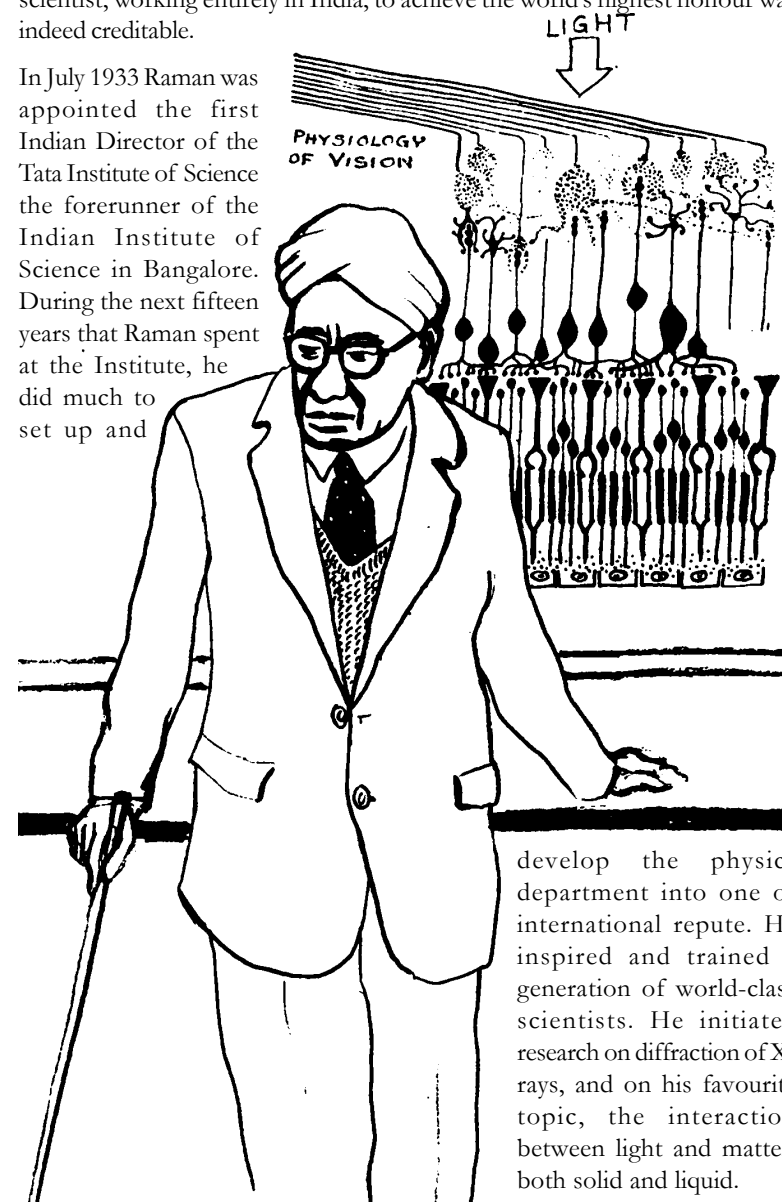
After returning to India Raman started serious research on this subject. He passed light beams through a variety of liquids and studied their effects. Finally in 1928, he established that when monochromatic (single colour) light was passed through a liquid; the light quanta and the liquid molecules interact and scatter the light. The emergent light is found to be of a different colour from the original beam. It is shifted to both higher and lower levels of energy, relative to the incident light. This is the famous *Raman Effect* which later won him the Nobel Prize. The discovery had a catalytic effect on research world-wide. It became a powerful tool to study the structures of different materials.



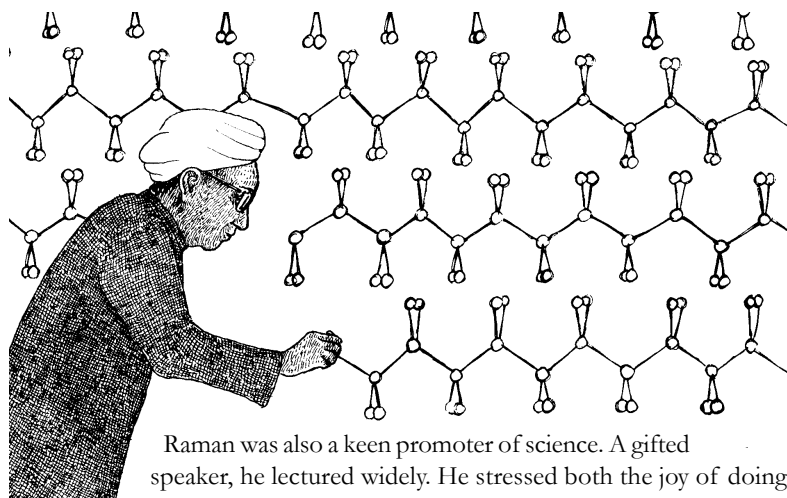
Recognition was not far in coming. Sir Ernest Rutherford announced the discovery of the *Raman Effect* in the Royal Society and the British government conferred a Knighthood. On 10 December 1930 came the highest award, the Nobel Prize. Raman was the first Asian and first non-white to get a Nobel Prize in science. Before him Rabindra Nath Tagore had received the Nobel Prize for Literature. Raman's nephew Subrahmanyan Chandrasekhar was later to win the Nobel Prize in 1983.

Subjugated by centuries of foreign rule this international honour enormously boosted the self-esteem of the Indian science community. For an Indian scientist, working entirely in India, to achieve the world's highest honour was indeed creditable.

In July 1933 Raman was appointed the first Indian Director of the Tata Institute of Science the forerunner of the Indian Institute of Science in Bangalore. During the next fifteen years that Raman spent at the Institute, he did much to set up and



develop the physics department into one of international repute. He inspired and trained a generation of world-class scientists. He initiated research on diffraction of X-rays, and on his favourite topic, the interaction between light and matter, both solid and liquid.



Raman was also a keen promoter of science. A gifted speaker, he lectured widely. He stressed both the joy of doing science and its key role in uplifting society. Sprinkled with good humour, his talks were simple yet profound. During his popular science lectures (or *performances* as he called them) Raman held his audience spellbound. His lectures were accompanied by lively demonstrations. His lecture on *Why the sky is blue?* is a veritable primer in communicating the scientific spirit and its method. Science is presented not as dry facts or formulas to be learnt by rote, but by way of step-by-step questioning. And by methodical reasoning, the working of nature is explained.

He was a founder member of the Indian National Science Academy (INSA).

Raman worked on the acoustics of musical instruments. He worked out the theory of transverse vibration of bowed strings, on the basis of superposition velocities. He was the first to investigate the harmonic nature of the sound of Indian drums such as the *tabla* and the *mridangam*.



He started a company called the Travancore Chemical and Manufacturing Co. Ltd. in 1943.

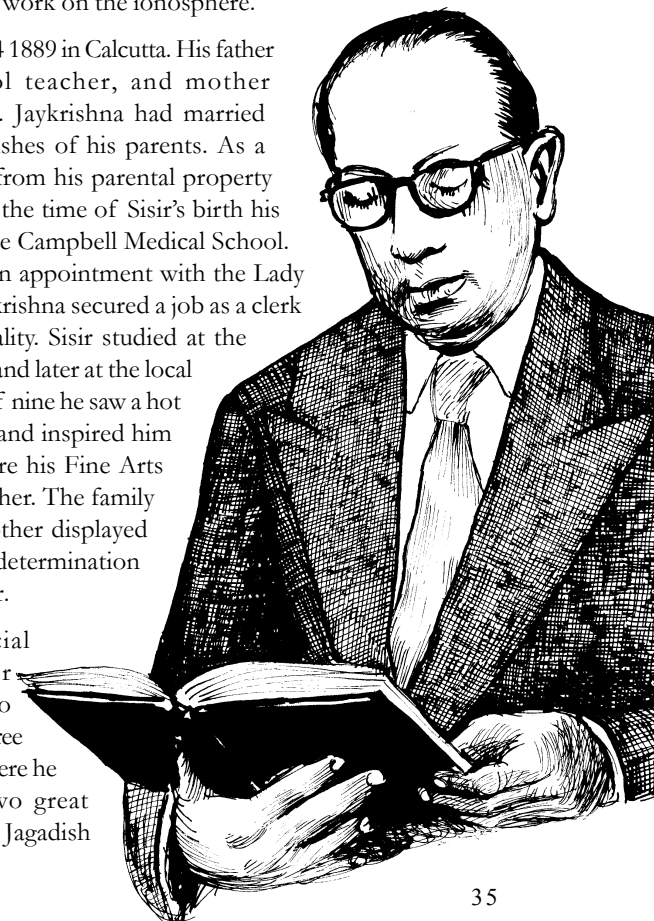
Before his retirement in 1948 Raman built up a research institute of his own, the Raman Research Institute in Bangalore. A notable feature of this institute was that it was funded entirely by private donations. He continued his research and exposition of science till 1970. On 2nd October 1970, he gave the customary Mahatma Gandhi Memorial lecture at the Raman Institute. Soon after he fell ill and on 21 November he passed away.



Prof. Sisir Kumar Mitra was the doyen of radio science in India. He was also well known for his seminal work on the ionosphere.

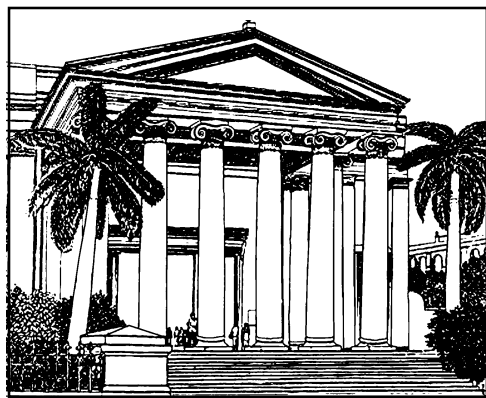
Sisir was born on October 24 1889 in Calcutta. His father Jaykrishna was a school teacher, and mother Saratkumari was a doctor. Jaykrishna had married Saratkumari against the wishes of his parents. As a result he was disinherited from his parental property and had to leave home. At the time of Sisir's birth his mother was a student of the Campbell Medical School. In 1889, Saratkumari got an appointment with the Lady Dufferin Hospital, and Jaykrishna secured a job as a clerk in the Bhagalpur Municipality. Sisir studied at the Bhagalpur District School, and later at the local T. N. J. College. At the age of nine he saw a hot air balloon. This intrigued and inspired him to study science. Just before his Fine Arts (FA) exam, Sisir lost his father. The family was devastated but his mother displayed indomitable courage and determination and brought up young Sisir.

Despite pressing financial problems Sisir's mother encouraged him to go to Calcutta to pursue a BSc Degree at the Presidency College. Here he was fortunate to have two great scientists as his teachers – Jagadish



Chandra Bose and Prafulla Chandra Ray. He was fascinated by the sundry low-cost devices invented by Bose and decided to pursue teaching and research as a career. He finished MSc physics in 1912 topping the merit list. For a short period he joined Bose as a researcher but he urgently needed a job to support his family. So he taught for a few years first at the T. N. J. College, Bhagalpur, and later at the Bankura Christian College. In 1914 he married Lilavati Devi.

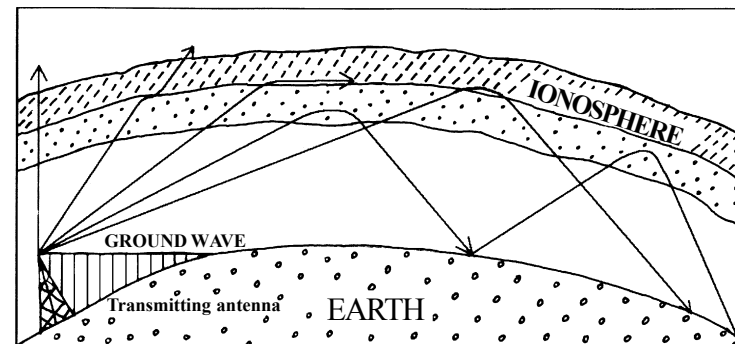
Sir Asutosh Mookherjee the then Vice Chancellor of Calcutta University was trying to initiate post-graduate teaching and research in science. In 1916, he managed to set up the University Science College, and invited Mitra, along with other highly talented scholars to join the physics department. This included luminaries like C. V. Raman, S. N. Bose and M.



N. Saha. Mitra worked under Raman's guidance on interference and diffraction of light. In just three years he completed his thesis and obtained a DSc from Calcutta University in 1919.

Soon thereafter he proceeded abroad for advanced research. He first worked under Charles Fabry at the Sorbonne University in Paris. In 1923 he obtained a second DSc degree. Later, he joined Madame Curie at the Institute of Radium. For a while he worked at the Institute of Physics, University of Nancy under Gutton. Here Mitra got deeply interested in radio valves and their applications. He decided that his future lay in advancing the new field of radio research. As this subject was not taught anywhere in India he requested Sir Asutosh to include *wireless* in the MSc curriculum and to set up a laboratory for experimental work.

Sir Asutosh supported his proposal and asked Mitra to prepare the necessary details and return to India. Mitra returned in 1923 and was appointed the Khaira Professor of Physics. This marked the beginning of radio electronics in India - teaching, research, setting up an experimental lab began in earnest. Soon the Calcutta University had a world class school of *radio research* now known as the Institute of Radio Physics and Electronics.



The real science of *radio* began with the discovery of the ionosphere. Mitra investigated the ionosphere - vital for long distance radio communication. It's a region in the upper atmosphere that reflects short radio waves enabling transmission around the curved surface of the earth. Using the medium wave transmitter used by the Calcutta station of the Indian Space Broadcasting Service, Mitra produced the first experimental evidence of the E-region of the ionosphere. He proposed that the luminescence in the night sky was caused by ions in the F-layer of the ionosphere. Because of this luminescence the sky was not pitch black and looked dusty. He wrote a series of papers relating to the ionosphere layers over Calcutta. He did excellent mapping of the ionosphere using very simple equipment. Though ionospheric chemistry was then, still in its infancy but even here Mitra made a beginning through detailed discussions of the formation and destruction of ozone.

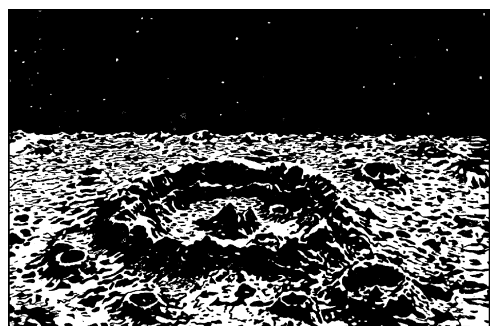
Mitra wrote a masterpiece on the ionosphere - *The Upper Atmosphere*. Foreign publishers were reluctant to publish the book as they thought it would compete with established foreign books! And yet when the book was published in 1947 by the Asiatic Society, 2000 copies were sold out within three years. Generations of students in radio communication, ionosphere and upper atmospheric physics, geomagnetism and space science have used this book as a major reference document. Mitra broke new ground by considering the ionosphere to be part of a vast panorama that interlinked the sun, the earth and the atmosphere.

In 1955 his book was translated in Russian. At the time of launching *Sputnik-I* in 1957, the Russian space scientists found that the only reasonable atmospheric models they could use for predicting the lifetime of satellites were those given in *The Upper Atmosphere*.

After retiring from the University in November 1955, Mitra continued as an Emeritus Professor. At the request of Bidhan Chandra Roy, the then Chief Minister of West Bengal, he restructured the ailing West Bengal Secondary Education Board into an efficient and disciplined organization. Despite his heavy schedule of work at the Board, Mitra continued his research and supervision at the Institute. Mitra trained scores of experimental scientists who later did pioneering work. Notable amongst his students were Prof. A. P. Mitra (FRS), M. K. Das Gupta (Radio Astronomer) credited with the discovery of the double radio galaxy CYGNUS-A, and Prof. J. N. Bhar.

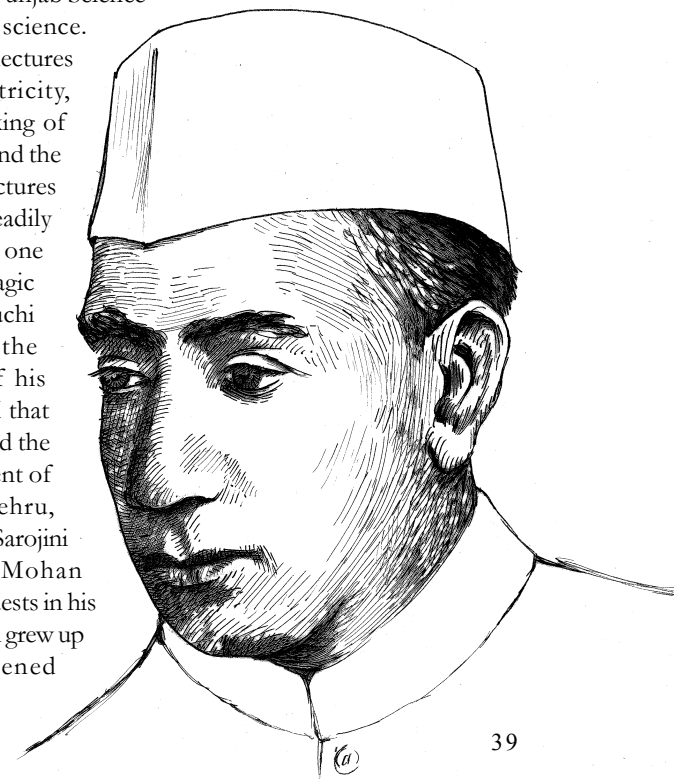
Mitra's family life was not very happy because of the premature death of his wife and elder son Dr. Ashok Mitra. The latter tragedy dealt a grievous blow on him. Soon after this however he was elected to the Fellowship of the Royal Society and also selected as a National Professor. He spent most of his spare time at home reading and writing. Every evening he used to visit the nearby Club for recreation and sometimes played a game or two of chess.

Mitra received many awards and honours, notable amongst them being the FRS (1958), he was the President of the Indian National Science Academy (1959-60), National Professor (1962), and was awarded the Padma Bhushan (1962). He breathed his last, after a brief spell of illness, on August 13, 1963. A crater on the moon has been named "*Mitra*" to immortalise the memory of this great scientist.



Often the discovery of a rare fossil can change the interpretation of evolutionary history. The person who laid the foundation for fossil research in India was Prof. Birbal Sahni. Early parental influence often shapes a child's personality and mindset. Young Birbal was fortunate in having an inspiring man for his father...Ruchi Ram Sahni who himself was a self-made man. Having worked with some of the greatest names in physics – Rutherford, Thompson and Bohr, he later set up the Punjab Science

Institute to popularize science. Ruchi Ram gave popular lectures on soap bubbles, electricity, magnetism and the working of the telegraph. Rural folk and the lay public attended his lectures in large numbers and readily gave the princely sum of one / two annas to see his magic lecture presentations! Ruchi Ram rebelled against the obscurantist dogmas of his times. He was convinced that education and science held the potential for the upliftment of the masses. Motilal Nehru, Gopal Krishna Gokhale, Sarojini Naidu, and Madan Mohan Malaviya were frequent guests in his Lahore home. Birbal Sahni grew up in such an enlightened environment.



Birbal Sahni was born on 14 November 1891 at Bhera, a small town in, what is now Pakistan. Even as a child he loved adventure. When 14, one day he took his younger brother and sister on a crab collecting mission. Armed with handkerchiefs and empty tins they descended steep ravines, climbed boulders and high cliffs and returned home only at night! But the liberal family took it in its stride. Birbal often accompanied his father on long treks to remote parts of the Himalayas. On these trips he invariably carried Hooker's *Flora Indica*. He spent considerable time identifying plants. Once while traversing the inaccessible Jo Jila Pass, he collected some *red snow*. It later proved to have been formed by a rare, snow inhabiting algae.

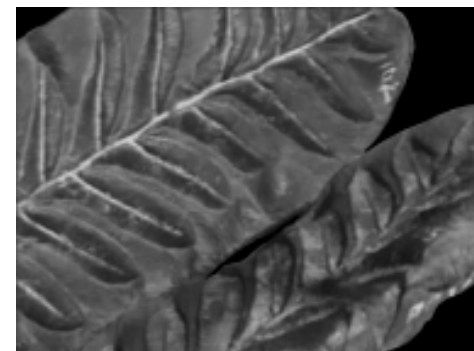
Birbal studied at the Mission and Central Model Schools in Lahore. In 1911 he graduated from the Government College, Lahore, where his father was a professor of chemistry. The same year he left for England and joined the Emmanuel College at Cambridge. He had no recommendations and was admitted on his own merit. But after a while he felt utterly homesick and desperately wanted to return home. But his elder brother – who was then studying medicine in London, persuaded him to return back to studies! After that fateful day Birbal Sahni never looked back and graduated from Cambridge in 1914. Ruchi Ram Sahni was then working in Rutherford's laboratory in Manchester. During vacations the young Birbal helped his father take photographs! Jawaharlal Nehru was his classmate at Cambridge. They both

shared a love for fossils. The friendship between Birbal and Nehru endured till the end.

Birbal's research output culminated in the publication, jointly with J.C. Willis, of *Laswon's Textbook of Botany*. For his contribution to the study of fossil plants, Sahni received in 1919 the DSc from the University of London. The thesis work was published in the *Philosophical Transaction* (1920), by which time Sahni emerged as an original thinker of botany.



While at Cambridge, Birbal developed a deep friendship with his teacher Prof. Seaward. The latter was sent some Indian fossils to study. He returned the specimens saying that Birbal Sahni in India would be the right man to study them! This compliment by Prof Seaward set Birbal on the path of serious research. In 1920 along with Prof Seaward he brought out the *Revision of Indian Gondwana Plants*.



*A plant that lived millions of years ago left its impression, which has been preserved in this rock.*



*By analysing fossils, Birbal Sahni was able to reconstruct what the extinct plant, Williamsonia looked like. It was one of the first flowering plants. (A) the plant; (B) a male flower; (C) a stamen; (D) a male flower of another species; (E) the microsporophyll.*

In 1921, he became the first professor of the newly opened Botany Department at Lucknow University. He would not only give lectures to the BSc classes but also help in practical work and take them for field visits. By this strategy, he could build up a very active school of research in botany. Apart from his profound knowledge he was adept at rapidly drawing excellent sketches, with both hands, on the black board. He was a workaholic and totally immersed himself in work. He could be seen all day and night cutting, grinding and polishing sections of fossils with his hands. Soon he mastered the art of preparing fossil and rock specimens.



He was the first Indian Botanist to be conferred the Fellowship of the Royal Society in 1936. He presided over several sessions of the science congress and was appointed an Honorary Member of the American Academy of Arts & Sciences.

Besides a deep love for science, Sahni pursued several hobbies. He had an abiding love for music and could play the *sitar* and the violin. He loved drawing and clay-modelling in his spare time. He was a chess addict. At school and college, he was keen on hockey and tennis. Being a nationalist he gave up the British attire and mostly wore a *khaddar sherwani*. As a child he imbibed a love for Sanskrit which he cherished till the end.

Sahni's research covered almost all aspect of palaeobotany in India. He collected a large number of fossil plants from the Rajmahal Hills of Bihar. Here he discovered a new group of fossil gymnosperms which he named *Pentoxylae*. He was also the founder member of the Indian Botanical Society.

Sahni had wide interests. His work on the *Technique of casting coins in ancient India* won him the Nelson Wright Medal of the Numismatic Society of India in 1945. During his study of fossils he had acquired a thorough knowledge of geology. His research threw light on the age of the Deccan Traps and the timing of the Himalayan uplift.

In 1920, Birbal Sahni was married to Savitri - who remained his constant companion in work and travel. Later he built a house on the banks of the river Gomti in Lucknow. In 1946, he founded a trust to promote research in palaeobotany. Sahni and his wife contributed the initial funds, immovable property, books and fossil collections for the



project. The Palaeo-botanical Society functioned from a single room in the Lucknow University. In 1948, the State government granted a piece of land for the new institute. Its foundation was laid on April 03, 1949 by India's first Prime Minister Jawaharlal Nehru. Birbal Sahni gave an inaugural address on the occasion which also happened to be his last speech. He died barely a week later of a severe heart attack on the midnight of April 09, 1949.

After Birbal Sahni's sudden death his wife Savitri Sahni worked hard to realize her husband's dream. She worked against heavy odds to put the Institute on a sound footing and helped it gain international recognition. For her efforts she was awarded the Padma Shri in 1969. In the same year the Institute was renamed the Birbal Sahni Institute of Palaeobotany in memory of this pioneering scientist.



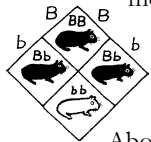
The Indian Postal Department issued several stamps saluting the work of Birbal Sahni - one species has been named as *Birbalsahnia divyadarshanii*.



*"No doubt I am in some sense a citizen of the world - but I believe with Thomas Jefferson that one of the chief duties of a citizen is to be a nuisance to the government of his state."*

-J.B.S. Haldane

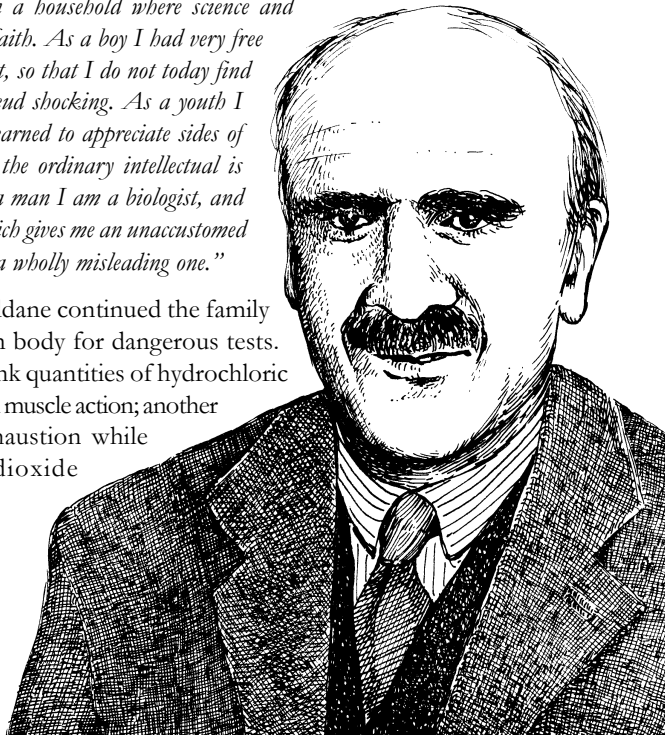
John Burdon Sanderson (J.B.S.) Haldane was one of the great eccentrics of modern science - independent, brilliant, funny and very unique.



Son of an Oxford professor of physiology, he began learning science as his father's assistant. He learned Mendelian genetics while still a boy by breeding guinea pigs.

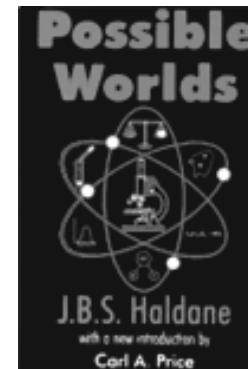
About his childhood Haldane wrote: *"As a child I was not brought up in tenets of any religion, but in a household where science and philosophy took the place of faith. As a boy I had very free access to contemporary thought, so that I do not today find Einstein unintelligible, or Freud shocking. As a youth I fought through the war and learned to appreciate sides of human character with which the ordinary intellectual is not brought into contact. As a man I am a biologist, and see the world from an angle which gives me an unaccustomed perspective, but not, I think, a wholly misleading one."*

A physically well built Haldane continued the family tradition of using his own body for dangerous tests. In one experiment, he drank quantities of hydrochloric acid to observe its effects on muscle action; another time he exercised to exhaustion while measuring carbon dioxide pressures in his lungs.



After completing his studies, Haldane taught genetics and biometry at University College, London. He was one of the three major founders of population genetics. He is usually regarded as the third of these in importance, after R. A. Fisher and Sewall Wright. Haldane's brilliance was in using the concepts of genetics to define natural selection in mathematical terms. This led to a new synthesis between Mendelian genetics and Darwinian evolution, which is the foundation of modern biology. In addition to his work in genetics, Haldane also made important research contributions to other areas of biology, chemistry, and mathematics, and also wrote extensively on history and politics.

In 1924, Haldane published a remarkable work of fiction, *Dadalus*. It was the first book about the scientific feasibility of *test-tube babies* brought to life without sexual intercourse or pregnancy. At the time, it was regarded as shocking science fiction. *Dadalus* was a popular and influential book, the original dose of *future-shock* for the 20th century. It inspired Aldous Huxley's novel *Brave New World* (1932), in which a society based on test-tube babies turns out to be not such a wonderful place after all.



Despite predicting its feasibility, Haldane later became an outspoken critic of eugenics. Genetic theory was being used for distorted political ends, he complained, by *"ferocious enemies of human liberty."*

In 1926, Haldane married Charlotte Burghes, a young reporter with the *Daily Express*.

He later divorced and married Helen Spurway - a biologist.

J.B.S. Haldane was very much concerned with human welfare. Being a liberal in his student days at Oxford, he veered towards the left and finally formally joined the Communist Party in 1942. Later he became the Chairman of the editorial board of the *Daily Worker* for which he wrote more than 300 articles on scientific themes often mixed with political comments.





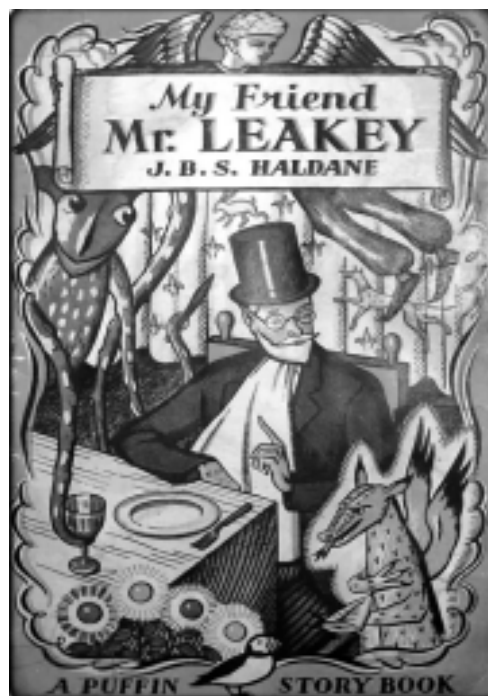
Haldane became a socialist because he believed that working people should also enjoy the advantages, which he himself enjoyed. Later events in the Soviet Union, such as the rise of Anti-Mendelian agronomist Lysenko and the crimes of Stalin, caused him to break with the Party, although he showed a partial support of Lysenko and Stalin.

Haldane's comments on the then existing educational system are still worth considering. He observed: *"Our present educational system is unjust to children because the majority of them don't get a fair chance and practically none are taught the truth of science from a human point of view. Science teaching should begin, not with a mythical body in rest or uniform motion, but with the human body. Mine did so begin at the age of three."*

In his essay, *On Being the Right Size*, Haldane conjectured that the sheer size very often defines what bodily equipment an animal must have: *"Insects, being so small, do not have oxygen-carrying bloodstreams. What little oxygen their cells require can be absorbed by simple diffusion of air through their bodies. But being larger means an animal must take on complicated oxygen pumping and distributing systems to reach all the cells."*

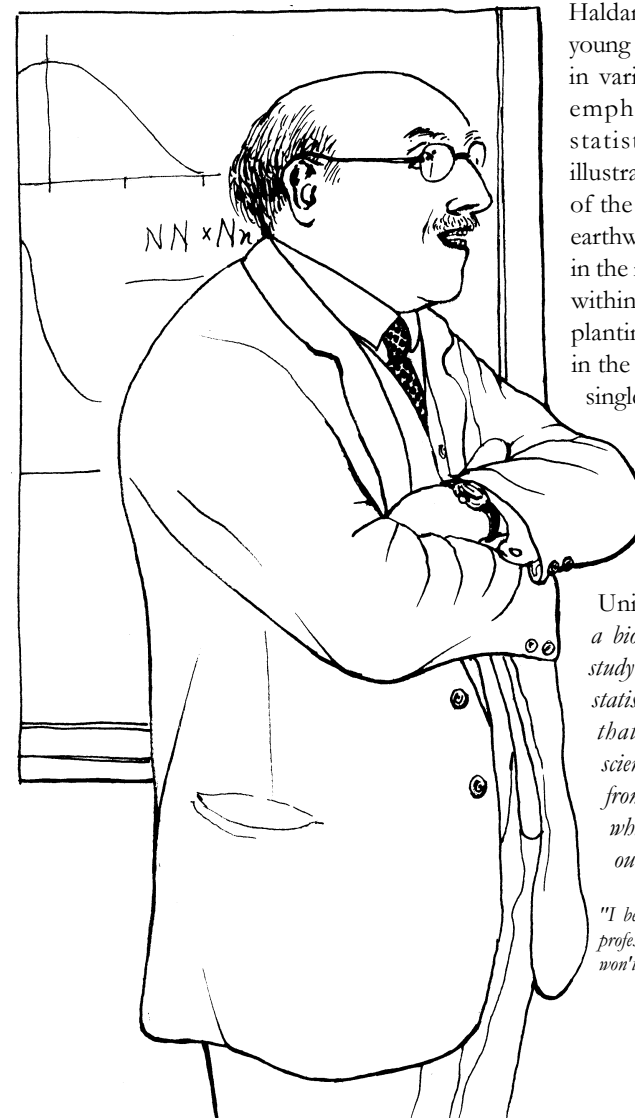
In 1937 he wrote *My Friend Mr. Leakey*. This is perhaps the only book he wrote for children. The enigmatic character of Mr. Leakey endeared him to children, and all his life he was thronged with letters from children.

Haldane was an outstanding science populariser. His writings were remarkably lucid. He had the ability to present complicated concepts of science in a simple way without distorting their meaning. His articles, lectures and broadcasts made him one of the best known science popularisers in the world. He trained and inspired coal miners in England to search for fossils. And whenever they found one he rewarded them with a prize of 10 Pounds.



In 1957 Haldane moved to India, ostensibly in protest against the Anglo-French invasion of Suez. His decision to move to India was also influenced by the country's facilities for research in genetics and biometry. He joined the Indian Statistical Institute (ISI), Calcutta, at the invitation of P.C. Mahalanobis.

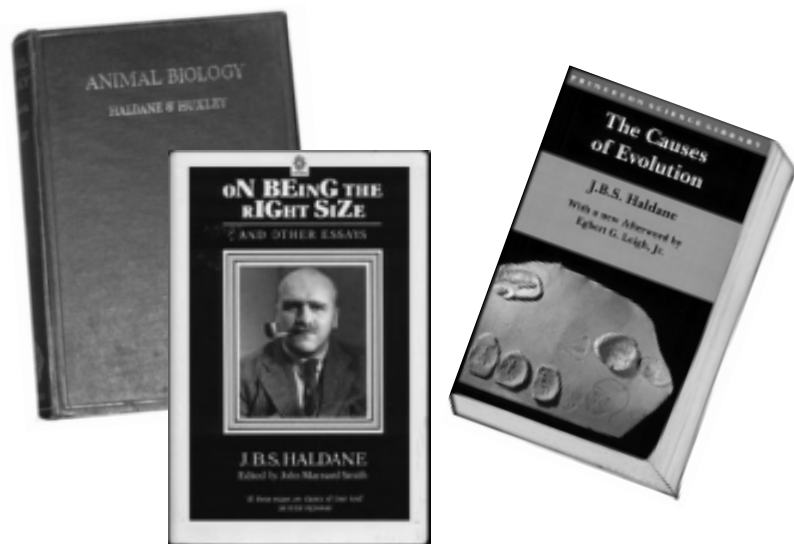
On his association with the Indian Statistical Institute Haldane observed: *"I owe a great deal to this institute but I undoubtedly owe most is the opportunity it has given me of making some important discoveries, namely, the discoveries of a number of younger men than myself, who, I think are in the great tradition of scientific research."* In 1962 he moved to Bhubaneswar to set-up the Genetics and Biometry Laboratory.



Haldane encouraged his team of young students to carry out research in various areas of biology, with emphasis on quantification, statistics and analysis. Some illustrative problems - estimation of the amount of earth moved by earthworms in a field; the variation in the number of petals on flowers within a single species; impact of planting different varieties of rice in the same plot as compared to a single species.

Haldane's role in improving biology teaching in India was phenomenal. He lamented that in Indian Universities *"Students who choose a biological course must give up the study of mathematics, not to mention statistics, at an early age. This means that graduates in the biological sciences are automatically debarred from most of the types of research, which would be of value in developing our agriculture and husbandry."*

*"I began to realize that, even if the professors leave politics alone, politics won't leave the professors alone."*



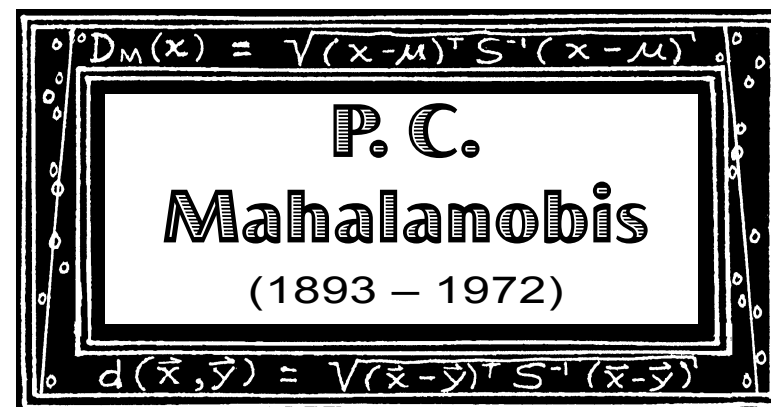
For his outstanding contributions Haldane received much recognition. He was elected a Fellow of the Royal Society in 1932. The Royal Society awarded him the Darwin Medal in 1953. The French Government gave him the Legion of Honour in 1937 and the Academia Nazionale dei Lincei gave him the Feltrinelli Prize (1961). He was President of the Genetical Society (1932-36).

Shortly before his death the irrepressible Haldane wrote an outrageous comic poem while in the hospital, mocking his own incurable disease:

*Cancer's a Funny Thing;  
I wish I had the voice of Homer  
To sing of rectal carcinoma,  
Which kills a lot more chaps, in fact,  
Than were bumped off when Troy was sacked...*

It was circulated among his friends, who savoured the consistently witty irreverence with which Haldane had lived his courageous and productive life.

He died on December 1, 1964. As per his will his body was sent to the Rangaraya Medical College, Kakinada. "My body has been used for both purposes during my lifetime", Haldane wrote in his will, "and after my death, whether I continue to exist or not, I shall have no further use for it, and desire that it shall be used by others. Its refrigeration, if this is possible, should be a first charge on my estate".



*"Statistics must have a clearly defined purpose, one aspect of which is scientific advance and the other human welfare and national development."*  
— P. C. Mahalanobis

The Professor, as Prasanta Chandra Mahalanobis was popularly known was a physicist by training, a statistician by instinct and an economist by conviction. It is interesting to note that his major achievements were in fields in which he had no formal degree. This is perhaps, a good example to emulate as the distinguished biologist J. B. S. Haldane said:

*"I consider it desirable that a man's or woman's major research work should be in a subject in which he or she has not taken a degree. To get a degree one has to learn a lot of facts and theories in a somewhat parrot like manner. It is rather hard to be highly original in a subject in which one has learned with a view of obtaining first class honours in an examination."*  
— J. B. S. Haldane



Mahalanobis was born on 29 June 1893 in Calcutta. He was the eldest of two brothers and three sisters. His family was wealthy and imbued with the liberal values of the Brahmo Samaj traditions. He had his early education in the Brahmo Boys School in Calcutta and obtained the BSc degree with honours in

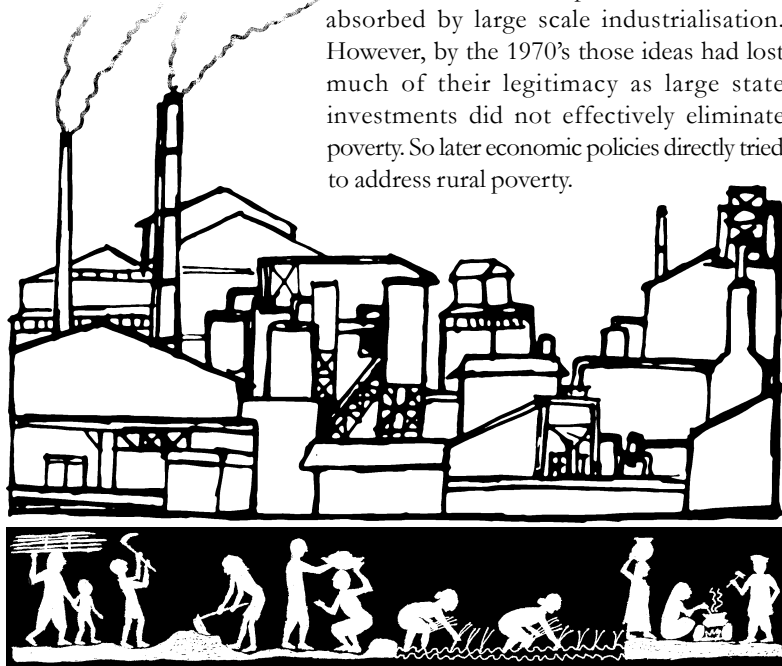
physics in 1912 from the Calcutta University. Mahalanobis was a contemporary and a friend of Satyendra Nath Bose and Meghnad Saha.

His wife Nirmalakumari was a major influence in his life and helped in all his endeavours. She too came from a very progressive family.

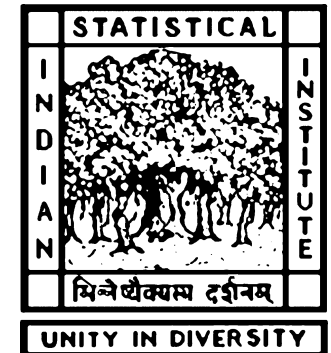
Mahalanobis's most remarkable and lasting contributions were the setting up of large scale surveys, the application of statistical theory to a variety of concrete Indian problems and the creation of world class institutions. After studying mathematics and physics at Cambridge, England, he worked for a while at the Cavendish Laboratory and returned to India in 1915 for a short vacation. He found many challenging problems in India and decided to stay back. He began teaching physics at the Presidency College where he analysed examination results using the statistical method. He enjoyed this work so much that he left physics and fell into love with facts, figures, graphs and charts. Before Mahalanobis arrived on the scene statistics was virtually unknown in India. The subject was not taught in any Indian University.

Mahalanobis was the pioneer of survey sampling techniques. Soon after Independence he was appointed statistical advisor to the newly formed cabinet. He drafted India's Second Five Year Plan in 1955 which envisaged rapid industrialisation to eliminate unemployment. He recommended large investments in heavy industries and steel factories. His views on planning reflected the economic crisis of the 1940's - a labour surplus which had to be

absorbed by large scale industrialisation. However, by the 1970's those ideas had lost much of their legitimacy as large state investments did not effectively eliminate poverty. So later economic policies directly tried to address rural poverty.



Fascinated by statistical methods he began studying these intensively and started a small statistical laboratory in the college. This evolved into the Indian Statistical Institute (ISI) in 1932. He also started publishing *Sankhya: the Indian Journal of Statistics* in 1933. He nurtured and edited the journal all his life. He founded the National Sample Survey (NSS) in 1950 and the Central Statistical Organisation (CSO) in 1951.



The ISI did pioneering interdisciplinary work and collaborated with leading scientists from all over the world. J. B. S. Haldane the famous British scientist migrated to India and joined the ISI as a regular staff member. Under his guidance the ISI soon became a leading centre in India for research in human and plant genetics. Norbert Wiener, the world renowned mathematician and father of "cybernetics" spent six months as a distinguished professor at the Institute.

Mahalanobis used statistical methods to better understand an enormous range of social and physical phenomena. In the early 1920's, he used data from the Anglo-Indian community in Calcutta to arrive at measures of differences in the physical characteristics of communities. In the 1930's the Central Jute Committee approached him to conduct a survey to estimate jute yield for the whole of Bengal. It was this large-scale survey that set the stage for the first round of NSS in 1950. These NSS rounds became the primary source of data for studies on Indian living standards and poverty.

What makes this list of achievements remarkable? When the NSS began, there were simply no large-scale surveys of its kind anywhere, let alone in the poorer parts of the world. More than four-fifths of the Indian population lived in villages and yet less than a third of these were connected by roads. The NSS attempted a low-cost survey to gather national data on the social conditions of households, many of whom lived in far flung areas. This required enormous technical expertise, energy, tenacity, and leadership that characterized Mahalanobis. Over the years India has produced several famous statisticians, most of whom have been associated with the ISI and some have made truly fundamental contributions. What distinguished Mahalanobis was the range of practical questions he was interested in and the seriousness with which he applied scientific methods to their exploration. "Statistics must have a purpose," was Mahalanobis dictum.

Mahalanobis received many awards from academic societies all over the world for his contributions to statistics and economic planning. He was elected a Fellow of the Royal Society (1945). He was the founder fellow of the Indian National Science Academy (1935) and its President (1957-58). He received honorary doctorates from Calcutta, Delhi, Stockholm and Sofia Universities. The Government of India honoured him with the Padma Vibhushan in 1968.

W. A. Deming the famous American statistician expressed his admiration for Mahalanobis in these words:

*"No country, developed, underdeveloped or overdeveloped, has such a wealth of information about its people as India has in respect of expenditures, savings, and time lost to sickness, employment, unemployment, agriculture and industrial production."*

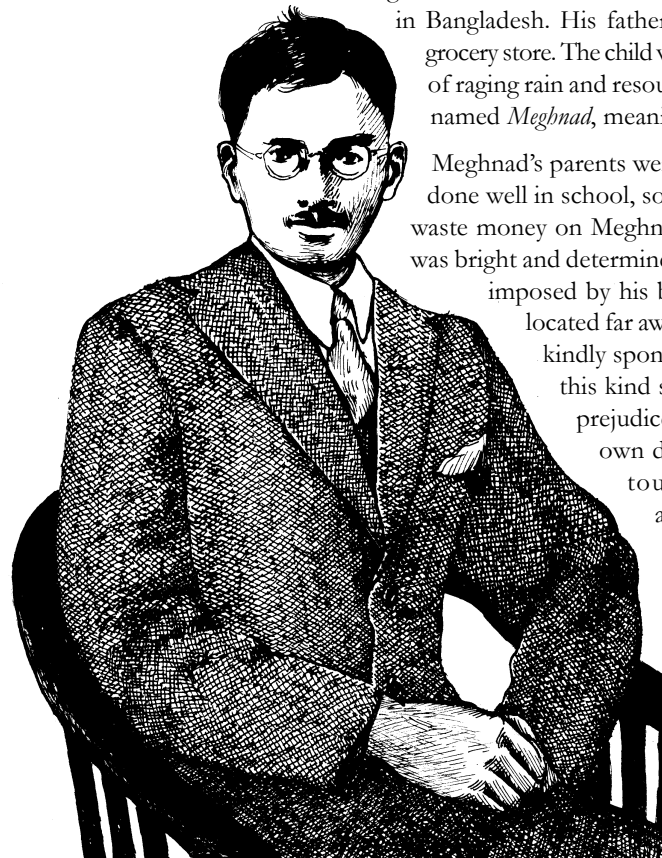
And for this we need to salute the father of Indian statistics – P. C. Mahalanobis who breathed his last on 28 June 1972 at the age of 79.



In a segregated society people of the lower castes are often persecuted and discriminated against. This prevents them from achieving their full potential. But it also inspires some gifted people to break the shackles. Dr. Meghnad Saha, a distinguished Indian scientist overcame crippling social constraints by sheer perseverance.

Meghnad Saha was born on 6 October 1893 in Seoratali, now in Bangladesh. His father Jagannath Saha ran a small grocery store. The child was born to the accompaniment of raging rain and resounding thunder and hence was named *Meghnad*, meaning the roll of thunder.

Meghnad's parents were poor. His brothers had not done well in school, so there was no good reason to waste money on Meghnad's schooling. But Meghnad was bright and determined to overcome the handicaps imposed by his birth. The middle school was located far away. Hence he had to live with a kindly sponsor near the school. But even this kind sponsor was not above social prejudices. Meghnad had to wash his own dishes – as no one else would touch them! But Meghnad accepted it stoically. He completed the Middle School in 1905, being placed first in Dacca division. He next joined the Collegiate School in Dacca City.



The game of *divide and rule* had helped the British in ruling India. Lord Curzon partitioned Bengal into an eastern and western part. Administrative convenience was the reason given. But since the two parts were Hindu and Muslim majority areas the British mischief was obvious. Nationalist Bengalis rose in revolt. The young Meghnad joined anti-British agitations for which he was expelled from school. Fortunately, another school accepted him. He completed Intermediate Science in 1911 and joined the Presidency College in Calcutta.

At Presidency College Saha was in the company of brilliant minds. Satyendra Nath Bose was his classmate; Subhash Chandra Bose his junior and P.C. Mahalanobis his senior. He had illustrious teachers in Sir J.C. Bose and P.C. Ray whose dictum: "*Science can wait, Swaraj cannot*" left a deep imprint on Saha. He completed BSc in 1913 and MSc in 1915, being placed second in the Calcutta University. His friend Satyendra Nath Bose stood first.

Saha faced social harassment and poverty in Calcutta. To supplement his meagre income he cycled all over town giving tuitions. After graduation Saha wanted to appear for the much sought after Finance Service Examination but he was debarred because of his political activities. In 1918, he was married to Radharani Roy.

Saha then joined the Physics Department at Calcutta University along with Satyendra Nath Bose. Saha was trained as a mathematician and it took him some time to master experimental physics.



The then rapidly developing Theory of Relativity and Quantum Mechanics attracted Saha. In 1917, he published his first scientific paper titled *On Maxwell's stresses, concerning the electro-magnetic theory of radiation* in the *Philosophical Magazine*. The Calcutta University awarded him the DSc degree in 1919.

After the First World War scientists discovered the deflexion of starlight by the gravitational field of the sun, confirming Einstein's theory

of relativity. Soon Saha became intensely interested in the field which now indelibly carries the mark of his contribution - the spectra of stars. In 1814 Fraunhofer had discovered a large number of dark lines in the *solar spectra*. In 1859

Kirchoff proved that these lines represented definite chemical elements. Helium was discovered in the sun before it was discovered on earth! Better spectrometers revealed bright as well as dark spectral lines. But the number of bright and dark lines far exceeded the number of elements known. This set the field in turmoil, until Saha came up with the solution. When a gas is heated some of its electrons are stripped away leaving positively charged nuclei and negatively charged free electrons. This process is called *ionisation*. Saha developed the theory of high thermal ionisation and its application to the interpretation of stellar spectra. Saha's *ionization equation* solved this riddle of Astrophysics and has been rated as an important milestone. With the help of this equation one can determine the ionization state of various elements making up a star.

A grant enabled Saha to visit Europe. In Germany he met eminent scientists like Einstein and Planck. Soon Saha was invited by Asutosh Mookherjee to take the post of Khaira Professor of Physics in Calcutta University. Saha returned to India in 1923. He later accepted an offer from Allahabad University and worked there for 15 years.

In 1927 at a young age of 34 Saha was elected a Fellow of the Royal Society. He delved deeply in nuclear physics. The (Paul) Dirac-Saha formula for calculating the pole strength of magnetic monopoles is a permanent reminder of his success in this field.

$$\log \frac{n_{r+1} P_e}{n_r} = -E_I \frac{5040}{T} + 2.5 \log(T) - 6.48 + \log \frac{2u_{r+1}}{u_r}$$

where:

$$u_r = g_0 + \sum_i g_i \cdot e^{-\frac{E_{ii}}{kT}}$$

Saha was not an *Ivory Tower* scientist. He involved himself in solving the problems of ordinary people. Spreading of scientific temper among people was a high priority with him.

In 1936 Saha left on an extensive study tour of Europe and USA. The research of Fermi, Heisenberg and Bohr gave the world the atom bomb. Saha earnestly believed in the peaceful uses of nuclear energy. In 1940, with a grant of Rs. 60,000 from the Tatas, Saha constructed a cyclotron and laid the foundation of nuclear research in India. With Nehru's help he set up the Institute of Nuclear Physics (fittingly renamed as Saha Institute of Nuclear Physics). Saha was also made the Director of the Indian Association for the Cultivation of Science for which he worked untiringly.

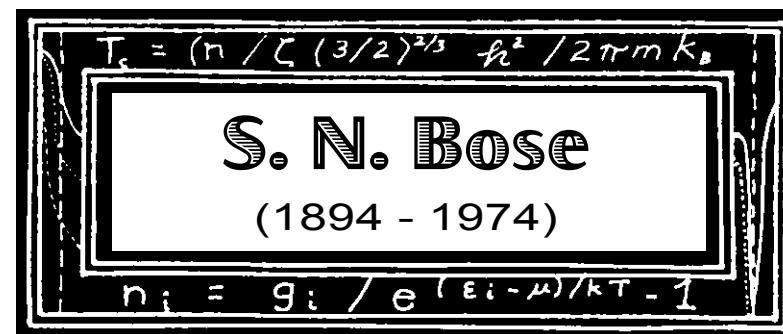
Saha was elected a Member of Parliament from the Calcutta North-West Constituency in 1952. His politics had a definite leftist orientation. His experience of obscurantism had turned him into a fervent rationalist, scornful of Indian superstitions. He founded the journal *Science and Culture* and edited it for a number of years.

Like many intellectuals, Saha believed that a planned economy was the salvation to India's economic problems. He had personally witnessed ravages caused by floods in his native Bengal. He strongly advocated River Valley schemes to control floods. This resulted in the Damodar Valley Corporation which built several dams to control floods.

Saha was perturbed by the irrational proliferation of numerous calendars in different regions of India. A Calendar Reform Committee was formed to rectify the defects, but because of deep biases it was only partly successful. Saha was also a strong believer in the linguistic reorganisation of India.

Saha was the founder of the National Academy of Sciences. He headed many committees of the Council of Scientific and Industrial Research. Saha was President of the Royal Asiatic Society of Bengal (now Asiatic Society) from 1944-46.

While on an official visit to Delhi, Saha suddenly collapsed and died due to a massive heart attack on 16 February 1956. His struggles and achievements proved that caste and poverty are not insurmountable barriers for the determined and courageous.

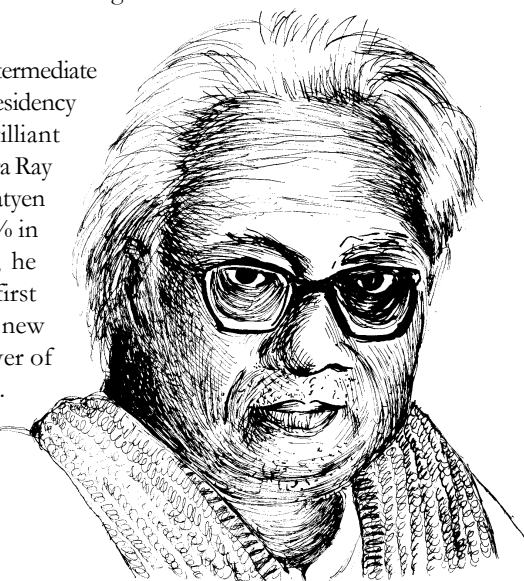


Though India has many scientists, it woefully lacks many great scientists. S. N. Bose was one such legend. He collaborated with Einstein and a class of microscopic particles known as *Bosons* carry his name.

Satyendra Nath Bose was born on 1 January, 1894 in Calcutta. His father Surendra Nath was an accountant in the railways. Bose initially went to the same school where Rabindra Nath Tagore studied for a short period. Later Satyen went to the Hindu School where his teacher Upendra Bakshi gave him 110 out of 100 marks in the mathematics exam because he showed several ways of solving the same problem in the given time!

After school Satyen cleared the Intermediate Entrance Exam and joined the Presidency College, Calcutta. Here his brilliant teachers included Prafulla Chandra Ray and Sir Jagadish Chandra Bose. Satyen was very bright and scored 100% in the Physiology exam. In 1913, he passed BSc honours and stood first in the merit list. He created a new record by scoring the highest ever of 92% marks in the MSc exam. Bose's classmate Meghnad Saha stood second on both occasions.

In 1914, while still a student Bose was married to





Ushabati, the daughter of a medical practitioner. In 1916 Bose was appointed Lecturer in the University College of Science. His colleague in the Physics Department was his friendly rival Meghnad Saha. Both were mathematically-oriented young men who, by their own self-study had gained proficiency in physics.

Bose published his first research paper on *The Influence of the Finite Volume of Molecules on the Equation of State* in the *Philosophical Magazine* of London in 1918. His next two papers were purely mathematical in nature.

In collaboration with Saha, Bose translated Albert Einstein's paper on the *Theory of General Relativity* from the original German into English. The British publisher objected to the translation but Einstein graciously gave his permission to these young Indian scientists.

In 1921 a new university was being formed in Dacca and its administrators, eager to attract a talented faculty invited Bose as a Reader. The facilities were primitive but Bose made up for the bad facilities at Dacca with his enthusiasm. Ever the perfectionist, he was dissatisfied with Max Planck's ways of deriving



some of his equations and produced a brilliant paper, *Planck's Law and Light Quantum Hypothesis* in which he worked out a rigorous derivation.

As no journal was willing to publish his paper so in 1924, Bose just thirty years old hesitantly sent it for comments to the celebrated Albert Einstein. So impressed was Einstein with Bose's paper, that he personally translated it into German and got it published in the German journal of science *Zeitschrift fur Physik*. Can any young physicist hope for a greater honour than this?

The collaboration between Bose and Einstein ultimately resulted in the well-known Bose-Einstein statistics used in quantum mechanics. Subatomic particles which obey Bose-Einstein statistics came to be known as *BOSONS* after Bose. Unlike other kinds of sub-atomic particles, an unlimited number of bosons may occupy the same state at the same time. Bosons tend to congregate together at the same lowest energy state, forming a *Bose-Einstein* condensate.

Three Generations of Matter (Fermions)				Bosons (Forces)
	I	II	III	
mass→	2.4 MeV	1.27 GeV	171.2 GeV	
charge→	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	
spin→	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	
name→	<b>u</b> up	<b>c</b> charm	<b>t</b> top	<b>γ</b> photon
Quarks	4.8 MeV $\frac{1}{3}$	104 MeV $\frac{1}{3}$	4.2 GeV $\frac{1}{3}$	0 0 1
	<b>d</b> down	<b>s</b> strange	<b>b</b> bottom	<b>g</b> gluon
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	
Leptons	<2.2 eV 0	<0.17 MeV 0	<15.5 MeV 0	91.2 GeV 0
	<b>ν<sub>e</sub></b> electron neutrino	<b>ν<sub>μ</sub></b> muon neutrino	<b>ν<sub>τ</sub></b> tau neutrino	<b>Z</b> weak force
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
Leptons	0.511 MeV -1	105.7 MeV -1	1.777 GeV -1	80.4 GeV ±
	<b>e</b> electron	<b>μ</b> muon	<b>τ</b> tau	<b>W</b> weak force
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1

Bose undertook a study tour of Europe in October 1924. He spent a year in France, working for a while in the laboratory of the famed Madame Curie. He spent one more year in Germany where apart from Einstein he interacted with other famous scientists - Lise Meitner, Otto Hahn, Wolfgang Pauli and Heisenberg. Berlin at that time was the science capital of the world. He learnt a lot in Berlin which he put to good use at Dacca. Bose built experimental facilities at Dacca and encouraged students to use them. This attracted good researchers like K.S. Krishnan who did seminal work on magnetic anisotropies and later published a number of papers.

The time Bose spent in Dacca was perhaps the happiest period of his career. However, he felt pained by the rising communal tensions. So after partition in 1947 he readily accepted the Khaira Chair at the University of Calcutta.

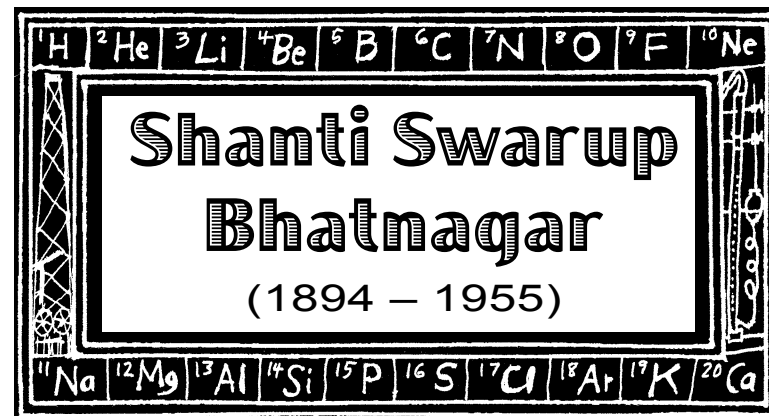
Professor P. A. M. Dirac had come to Calcutta along with his wife in the mid-fifties. They were sharing the same car with Bose. Bose let them have the back seat. The front seat, which Bose occupied along with the driver, did not have much room; nevertheless Bose asked some of his students to get in. Dirac, a little surprised, asked if it wasn't too crowded. Bose looked back and said in his disarming fashion, "*We believe in Bose statistics,*" Dirac explained to his wife, "*In Bose statistics things crowd together.*"

Research grants in universities were ridiculously low in those days. For example Bose and other professors were allowed Rs. 2,500/- per year! Nevertheless, Calcutta University gained fame as an active and creative research centre in India. Drive and determination compensated for paucity of resources.

Bose's laboratory became a centre for excellence in X-ray crystallographic studies. He was made the President of the Indian Physical Society for the period 1945-1948. Subsequently he was awarded the Padma Vibhushan in 1954 and in 1958 elected a Fellow of the Royal Society of London. Bose's last significant scientific contribution was towards the evolution of a *Unified Field Theory*, which tried to combine electromagnetic forces and gravitational forces. But success still continues to elude the scientific community.

In 1956, Bose became the Vice Chancellor of Visvabharati, better known as Shanti Niketan, forever associated with the memory of Rabindra Nath Tagore. The ideal of the institution to achieve a synthesis between Science and Spiritualism, between the ancient East and Modern West was naturally what attracted Bose. With his natural friendliness he also had no difficulty in getting on well with everybody. But administration was not his forte and his reforms evoked fierce resistance. So he was relieved to return back to Calcutta University in 1959.

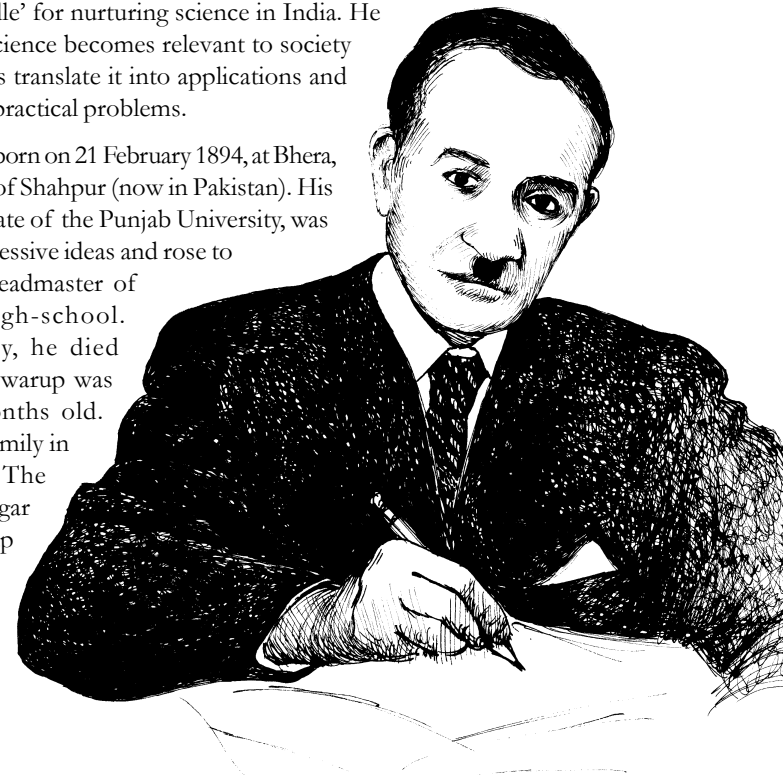
Bose was a complex character, not easily classified. As a brilliant mathematician he wrote only 25 papers – an appallingly meagre output! The entire field of knowledge was his province. He worked in as diverse fields as chemistry, mineralogy, biology, soil science, philosophy, archaeology, the fine arts, literature and languages. He was extremely fond of instrumental music and played the *esraj* like a maestro. He often discussed mural paintings with Jamini Roy. Tagore dedicated his book *Visva Parichay* (Introduction to the Universe) to Bose. He was keenly interested in popularizing science in the vernacular and inspired the setting up of *Bangiya Bijnan Parishad* which started the publishing of *Jnan O Bijnan* (Knowledge and Science) a popular science magazine in Bangla. He strongly believed that higher level scientific thinking was possible only in the mother tongue. He abhorred protocols and anybody could meet him without any appointment. He spent hours conversing with his friends and never considered it a waste of time.



*"I can truly say that for Dr. Bhatnagar you could not have seen today the chain of national laboratories."*  
— Jawaharlal Nehru.

Shanti Swarup Bhatnagar along with Bhabha, Mahalanobis and Sarabhai played a key role in building India's scientific infrastructure after independence. Bhatnagar apart from being an eminent scientist also created institutions which became a 'cradle' for nurturing science in India. He showed that science becomes relevant to society when scientists translate it into applications and use it to solve practical problems.

Bhatnagar was born on 21 February 1894, at Bhera, in the District of Shahpur (now in Pakistan). His father, a graduate of the Punjab University, was a man of progressive ideas and rose to become the headmaster of the local high-school. Unfortunately, he died when Shanti Swarup was just eight months old. This left the family in dire poverty. The young Bhatnagar was brought up by his maternal



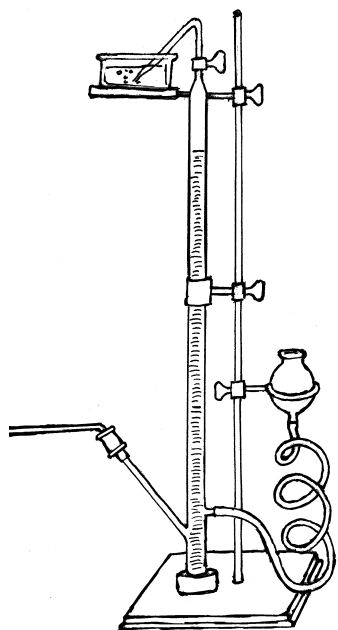
grandfather Pearey Lal – a distinguished engineer from the Roorkee College of Engineering. Shanti Swarup developed a taste for science from an early age. He would assemble mechanical toys and tinker around with his grandfather's gadgets. Here he was also exposed to good Urdu poetry and literature.

Shanti Swarup had his earliest schooling in a private *maktab*. Until 1907, he studied at the A. V. High School in Sikandarabad, UP. He was later persuaded by a family friend to move to Lahore where he attended the Dayal Singh High School. Here he excelled in both science and Urdu. In 1911, at the age of 17 he published his first paper in *Leader* published from Allahabad, on a method of making substitute carbon electrodes for a battery by heating molasses and carbonaceous matter under pressure.

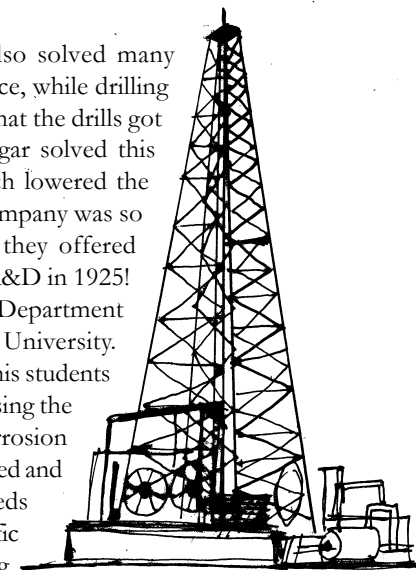
In 1916, Shanti Swarup completed BSc in physics from the Forman Christian College, Lahore. In 1919, he finished MSc in chemistry from the same college. It seemed the system of education was more flexible then. A graduate student in those days could switch from physics to chemistry; a feat impossible to imagine today! With a scholarship from the Dayal Singh College for higher

studies, Bhatnagar left for America via England. But since this was during the First World War, he found it difficult to get a ship for America, so he decided to stay back in England. He joined the University College, London and worked under Prof. F. G. Donnan - a distinguished physical chemist. He was awarded a DSc degree in 1921 for his thesis *On solubility of bivalent and trivalent salts of higher fatty acids in oils and their effect on the surface tension of oils*.

Bhatnagar returned to India in August 1921 and he joined the Banaras Hindu University (BHU) as Professor of Chemistry. During his short three years stay at BHU he created an active school of chemical research. He also penned the ceremonial Hindi hymn (*Kulgeet*) of the BHU. In 1924 he moved to Punjab University, Lahore as the Director of the University Chemical Laboratories where he stayed on until 1940. In these 16 years he published over a 100 papers. This was perhaps the most active period of his original scientific research. Apart from contributing to the field of



colloidal and magneto-chemistry he also solved many practical industrial problems. For instance, while drilling for oil, the Attock Oil Company found that the drills got stuck in mud and saline water. Bhatnagar solved this ingeniously by adding Indian gum which lowered the viscosity of the mud suspension. The company was so thrilled by this practical research that they offered Bhatnagar a sum of Rs. 1, 50,000/- for R&D in 1925! Bhatnagar used this money to set up the Department of Petroleum Research at the Punjab University. During the next ten years Bhatnagar and his students did pioneering research on waxes, increasing the flame height of kerosene, lubrication, corrosion prevention etc. Several patents were licensed and granted. Fifty percent of all royalty proceeds were used by the University to fund scientific research. Bhatnagar combined pioneering basic research with practical problem solving as they were the two sides of the same coin. He created wealth out of knowledge, recognizing the value of intellectual property long before it gained currency.



In the 1930s there were no research labs for the development of India's natural resources and industry. Just before the outbreak of the Second World War the Government of India established the Board of Scientific and Industrial Research. In December 1939, Bhatnagar was appointed as Advisor on Scientific and Industrial Research to the Government of India. Thus began his fifteen year long association with the Council of Scientific & Industrial Research (CSIR) established on 26 September 1942.

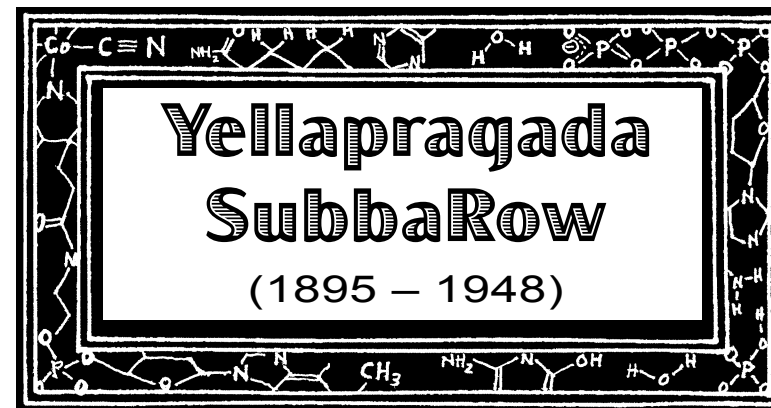
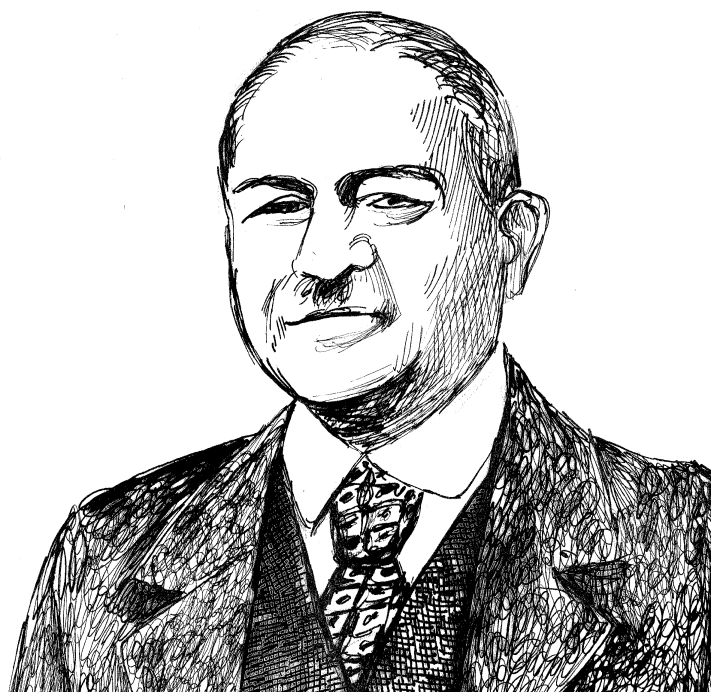


Bhatnagar created a clear blue print for the CSIR. Old timers recall with a chuckle how Bhatnagar would meet Nehru during the latter's morning walk, get approval for a new laboratory and have the paperwork ready by the time the office opened! It is to the credit of Bhatnagar that at the time of his demise 12 national labs were already functional – which included big institutions like the National Chemical Laboratory in Pune and

the National Physical Laboratory in Delhi. He set up the Indian Rare Earths Ltd to exploit the rich monazite sands of Kerala. He was also instrumental in setting up several private sector oil refineries. Bhatnagar held many high offices. He was the Secretary of the Atomic Energy Commission; Director, Council of Scientific and Industrial Research and Chairman, University Grants Commission. Many honours came his way, some significant ones being the Order of the British Empire (OBE) in 1936, Knighthood in 1941, Fellowship of the Royal Society in 1943 and several honorary degrees.

Bhatnagar was greatly influenced by the Brahmo Samaj in his formative years. He was deeply attached to his wife Lajwanti. A romantic at heart, he nursed the hope of becoming a farmer after retirement - and the hope that his wife would bring him lunch and a pot of butter milk in the fields!

He died of a heart attack on 1 January 1955. Bhatnagar achieved a great deal in his eventful sixty years. He left an indelible imprint on pure science. He believed in the application of science to help solve the country's economic problems. As a visionary he saw the need for a strong science infrastructure for an independent India. The CSIR seed sown by him has slowly grown into a giant tree. Today the 38 CSIR labs conducting research in widely diverse areas as Aerospace, Biotechnology and Chemistry... virtually constitute the *ABC* of Indian science.

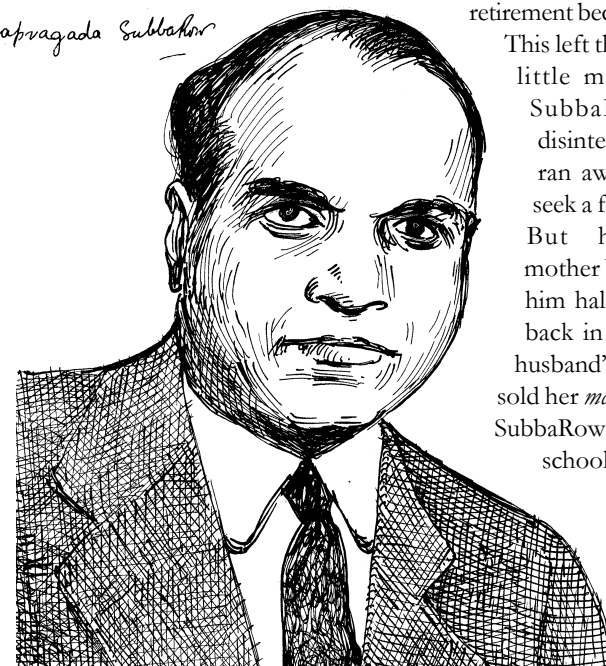


*"You've probably never heard of Dr. Yellapragada SubbaRow. Yet, because he lived, you may live longer." – Doron K. Antrim*

The *New York Herald Tribune* described Dr. Yellapragada SubbaRow as "*An eminent medical mind of the century.*" He discovered cures for many killer diseases which brought great relief to millions of suffering people throughout the world.

SubbaRow was born on January 12, 1895 in Bhimavaram in the West Godavari district of Andhra Pradesh. He was the third of seven children. His father Jagganadham took premature retirement because of bad health.

*Yellapragada SubbaRow*



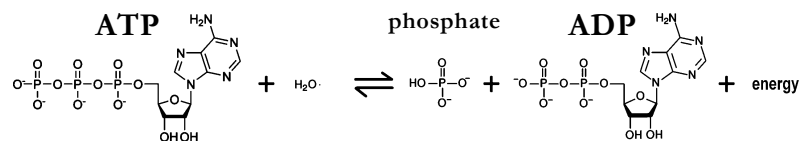
This left the family with very little money. At school SubbaRow remained disinterested and lost. He ran away from home to seek a fortune in Varanasi. But his determined mother Venkamma caught him halfway and put him back in school. After her husband's death Venkamma sold her *mangalasutram* so that SubbaRow could continue his schooling.

As a student of the Presidency College, SubbaRow spent most of his time at the Ramakrishna Mission. He had a strong ascetic streak in him and wanted to become a *sanyasi*. But his mother strongly disapproved of it. Finally, he joined the Madras Medical College so that he could later serve in one of the Mission's hospitals. But as his family could not support his medical studies he chose a typically Indian solution – got married and sought his father-in-law's help! SubbaRow's mother welcomed the decision for a different reason. She hoped it would cure him of his 'madness' for religion! Accordingly, on 10 May 1919, SubbaRow got married to Seshagiri, twelve years his junior. Seshagiri was destined to enjoy very little time with her husband on account of his consuming passion for work.

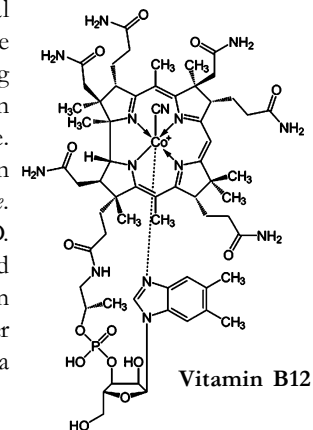
Influenced by Mahatma Gandhi's *Swadeshi* movement, SubbaRow boycotted British goods and started wearing a *kehad* gown. This offended his English professors, incurred their wrath and cost him the MBBS degree. When he was awarded the lower ranking LMS certificate he decided against western medical practice and joined the Madras Ayurvedic College as a lecturer in Anatomy.

A visiting American doctor encouraged him to go to the USA for further studies. Supported by a charity and his father-in-law, SubbaRow set off, promising his wife, still in her teens, that he would return in three years. However, he was never to see her again. He arrived in Boston on October 26, 1923 with 100 dollars in his pocket. His LMS medical degree did not qualify him to get a scholarship or an internship. In the initial period SubbaRow's professor Dr. Richard Strong helped him with fees and living expenses. In his spare time SubbaRow supported himself by cleaning hospital bedpans and doing other odd jobs.

He finally managed to get a diploma in Tropical Medicine from the Harvard Medical School and joined the biochemistry laboratory of Dr. Cyrus Fiske. Here he devised the now famous Fiske-SubbaRow method for estimation of phosphorous in blood and urine. This very sensitive procedure has now become a classic and is today taught to all biochemistry students. In recent years, it has become an important tool to diagnose disorders of the thyroid and renal rickets.



This method also helped SubbaRow to demolish the claim that glycogen was the fountainhead of energy required for muscular contraction. This claim had won Hill and Meyerhof, the 1922 Nobel Prize for medicine and physiology. SubbaRow discovered that adenosine triphosphate (ATP) provided the energy for every biochemical process including muscle contractions. Thus, a resting muscle has a higher concentration of ATP than a fatigued muscle. These findings were published in the April 1927, issue of *Science*. This research earned him a PhD. SubbaRow now commanded high respect and people held him in awe. It also led to the Rockefeller Foundation offering him a Fellowship.



SubbaRow next took up the challenge of pernicious anaemia, which afflicted many. He extracted vitamin B12 from pig liver which proved effective against anaemia. This set off a world-wide search for more vitamins, yielding a rich harvest in subsequent years.

SubbaRow thought that the giant pharmaceutical firms might offer greater scope for research than universities. So in 1940, he joined the world-renowned Lederle Laboratories. Here after a long struggle he succeeded in synthesising folic acid. In the last fifty years folic acid, along with vitamin B12 has proven itself very effective against the prevention of anaemia.

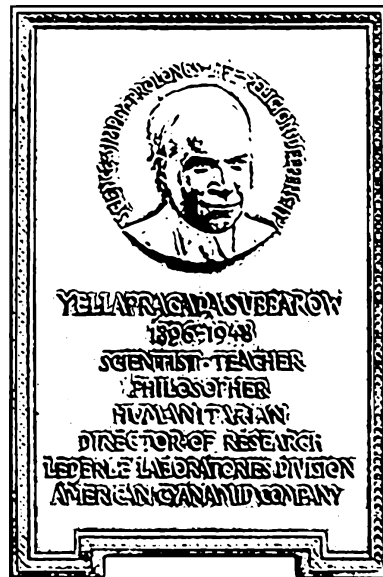
SubbaRow's research team was engaged in a battle against a whole range of human sufferings. He led his team from the front. As an MD he motivated PhD's to help alleviate human ailments, and as a PhD he inspired MD's to help him fashion chemicals to combat specific microbes. SubbaRow was a complete scientist – a chemist amongst chemists and a clinician amongst clinicians.

His last search was for a panacea – a cure for all fevers. In 1928, Alexander Fleming discovered the power of the penicillin mould to destroy germs. Thus was born the golden age of *antibiotics*. SubbaRow was too perceptive to miss the message and set up his own research into antibiotics. He hired a botanist to screen moulds from samples of soil, brought from all over the world. Finally, he succeeded in growing mould A-377, which was “*deadly like a cobra to a broad spectrum of disease germs and yet mild like a kitten to their animal hosts.*” This resulted in the development of *tetracycline* - one of the most widely used broad-spectrum antibiotics.

SubbaRow was constantly raising his sights and his next targets were cures for polio and cancer. One of the medicines he developed, *teorpterin*, proved effective against one type of cancer - leukaemia.

On the morning of Monday, 9 August 1948, his associates noticed his absence at work. SubbaRow was an obsessive workaholic so this was very unusual. On opening his apartment he was found dead of a massive heart attack. He was just 53. After leaving India he had never returned to his native land.

SubbaRow never sold his scientific discoveries, nor did he seek patents for any of his drugs. He shunned interviews to the press, awards, honours and recognition. SubbaRow's birth centenary was celebrated in 1995. His name was recommended for the country's highest civilian honour – the Bharat Ratna. SubbaRow insisted on remaining an Indian citizen even after his entitlement to American citizenship. And, although he made his contributions abroad, they all came from his India-born talents, drives and inspirations. Money and fame mattered little to him. He remained focused on finding cures for dreaded diseases and thus improved the well being of the whole of humanity.



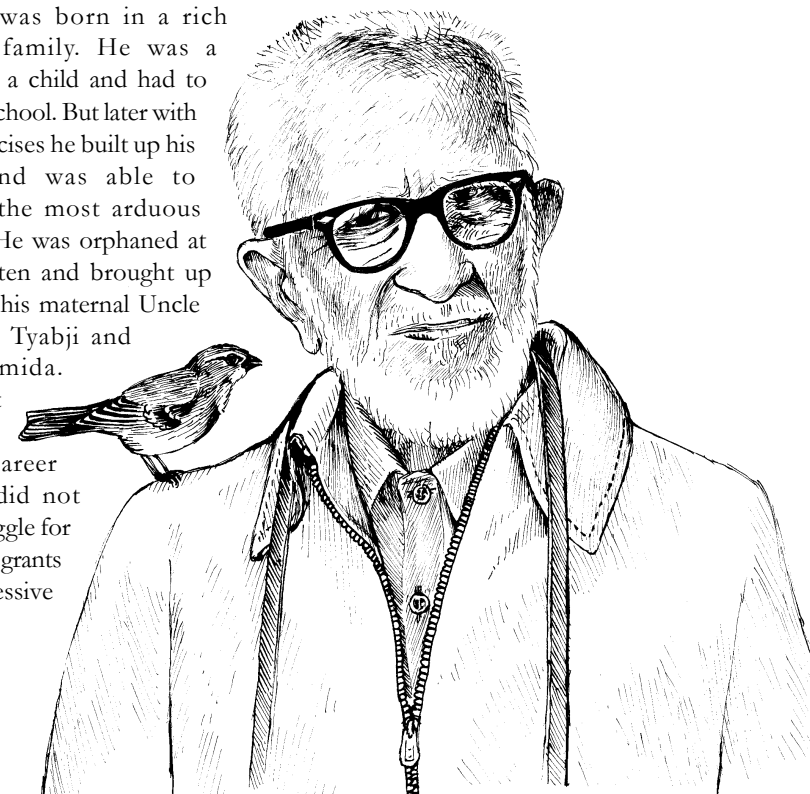
*“...Your message has gone high and low across the land and we are sure that weaver birds will weave your initials in their nests, and swifts will perform parabolas in the sky in your honour.”*

*– Paul Getty Conservation Prize Citation (1976)*

Salim Ali was indisputably the greatest field biologist of twentieth-century-India. Known as the *Birdman of India* he meticulously observed and documented the birds of the sub-continent for almost 80 years.

Salim Ali was born in a rich merchant family. He was a weakling as a child and had to often miss school. But later with regular exercises he built up his stamina and was able to withstand the most arduous field trips. He was orphaned at the age of ten and brought up lovingly by his maternal Uncle Amiruddin Tyabji and aunt Hamida.

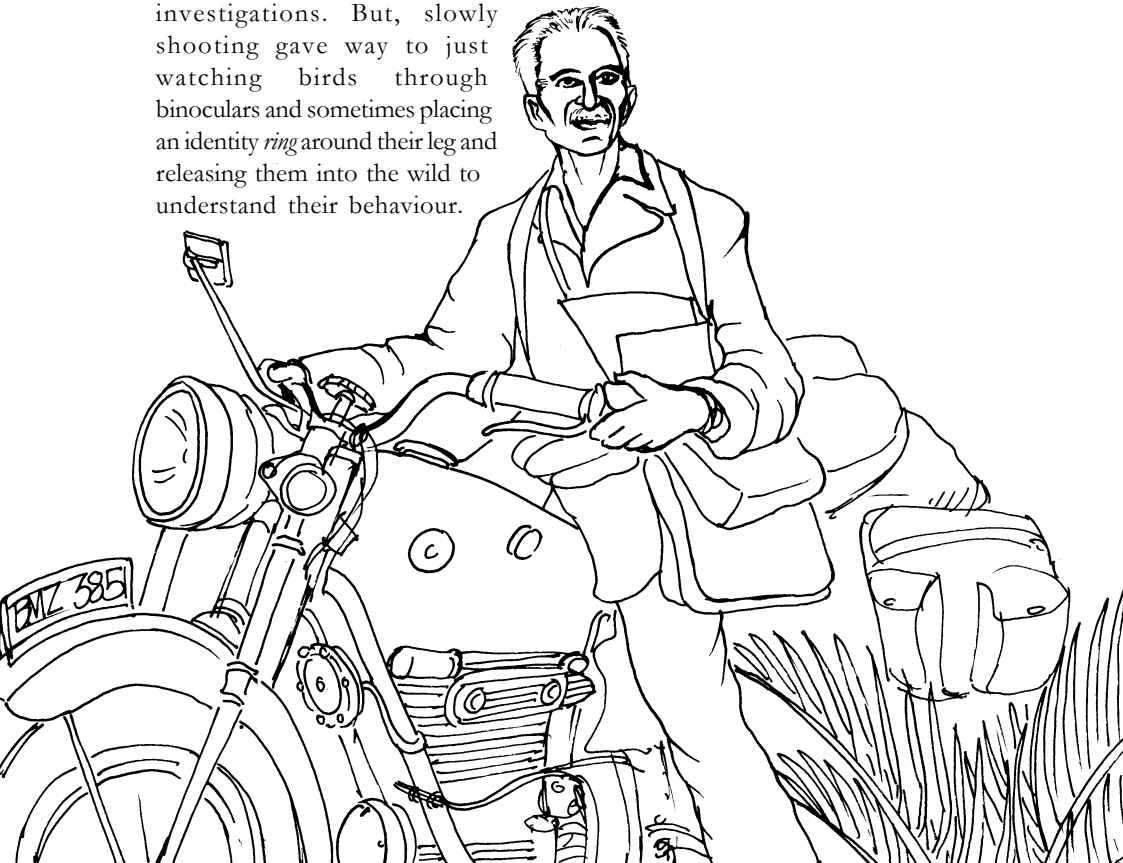
Throughout his long research career Salim Ali did not have to struggle for government grants as his progressive



family stood solidly besides him and supported his work. He studied zoology at the St. Xavier's College, Bombay but dropped midway to look after the family's tungsten trade in Burma. As business did not interest him, he returned to biology. In 1918, he married a distant relative Tehmina.

After failing to get a job with the Zoological Survey of India he worked for a while as a guide lecturer in the Prince of Wales Museum in Bombay. In 1928, he went to Germany and trained under Prof Erwin Stresemann at the Zoological Museum of Berlin. In 1930, finding no suitable employment he moved to Kihim a coastal village near Mumbai. Here he studied the breeding biology of bay birds which won him recognition as a world class ornithologist. He found that it is the male bay which builds the nest. Then suddenly one day the female arrives and takes possession of a husband and the half-finished home! He found that the thousands of baby bays were fed on soft bodied insects as the young are incapable of digesting hard grain. Adult bays were thus valuable biological controllers of insect pests. Salim Ali recommended the teaching of Economic Ornithology in all Agricultural Universities.

Salim Ali at times shot birds - some for the pot but largely for scientific investigations. But, slowly shooting gave way to just watching birds through binoculars and sometimes placing an identity ring around their leg and releasing them into the wild to understand their behaviour.



His studies unravelled the role of flower peckers and sunbirds in pollination and dispersing the seeds of the mistletoe. He also studied the Flamingos of the Rann of Kutch in depth. He did regional bird surveys of Hyderabad, Travancore, Cochin, Afghanistan, Kailash Manasarovar (China), Kutch, Mysore, Goa, Sikkim, Bhutan and Arunachal Pradesh. He showed that several species of the waterfowl migrated all the way to Siberia. All throughout, he maintained the most meticulous records and distilled his knowledge into a series of superbly written and illustrated books; he began in 1941 with *The Book of Indian Birds*, and followed this by *The Birds of Kutch*, *Indian Hill Birds*, *Birds of Kerala*, *Birds of Sikkim*, and finally his magnum opus, the ten volume *Handbook of the Birds of India and Pakistan*. His last bird book, the *Field Guide to the Birds of Eastern Himalaya* was published in 1977. In 1985 he wrote his charming autobiographical account, *The Fall of a Sparrow*. His deep understanding of bird life and the fragile eco-system led him to conservation. It was at Salim Ali's advice that the *Silent Valley* – a unique ecosystem and the *Bharatpur Bird Sanctuary* were established. His total dedication to science and to nature conservation was unique. He ensured the survival of the 200-year old *Bombay Natural History Society* (BNHS) by personally writing to Pandit Nehru for financial help.



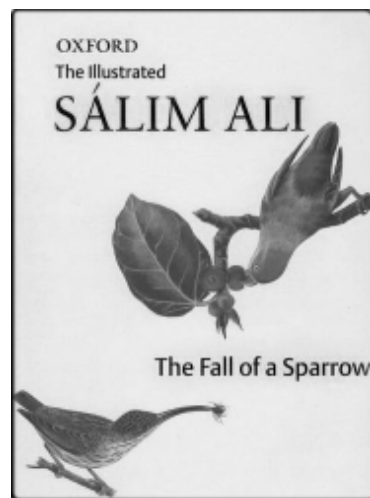
India is one of the top twelve mega diversity countries of the world. But still there exists no comprehensive documentation of its flora and fauna. Old records show the Mughal King's interest in natural history. For instance, Emperor Jehangir meticulously recorded the description of living beings along with the breeding behaviour of the Sarus Crane in his diary. He commissioned a talented artist Mansur to draw coloured pictures of birds. But this was followed by a long dark period of neglect. Indian philosophy considered external reality as *maya* – an illusion. So why study or document it? This led to the gradual decay of the biological sciences.

The British took up field work and documentation of India's flora and fauna for their colonial interests. Stalwarts like Sir Joseph Hooker, Hugh Whistler

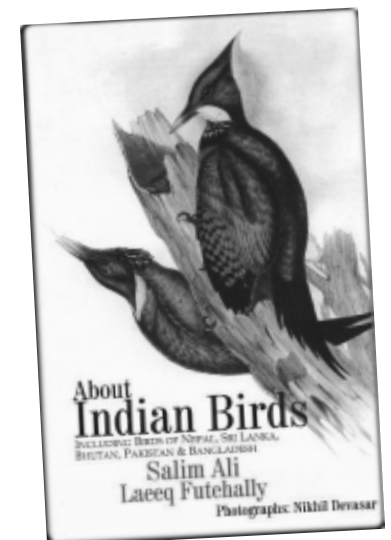
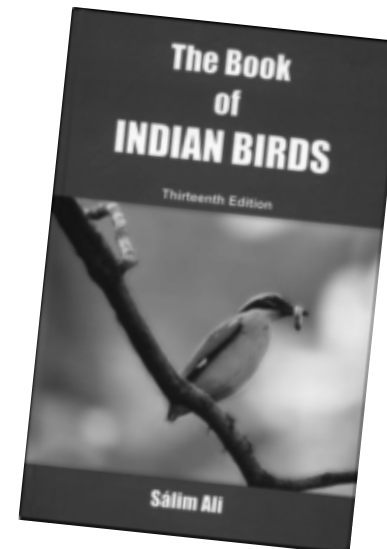
and Winter-Blyth did pioneering work in documenting India's biodiversity. Salim Ali was perhaps the first Indian scientist whose work was grounded in careful, painstaking observations. This made his work unique in the annals of Indian science.

Salim Ali's wife died in 1939 following a minor surgery and for the next five decades his sister's family took total care of his needs. Salim Ali was able to do so much and devote his entire life to the study of birds simply because his family accepted what other Indian families would undoubtedly have dubbed as madness. J. B. S. Haldane praised Salim Ali for his capacity to do the most meaningful scientific research with literally his bare hands holding a pair of binoculars.

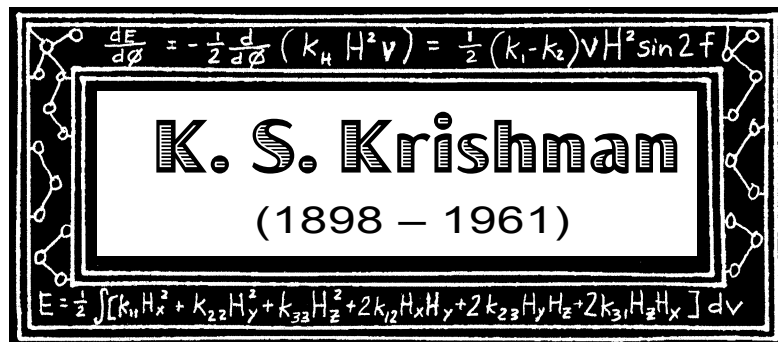
Once he caught a grey wagtail by placing a few strands of horsetail hair in front of a mirror in his lawn. The bird attacked its image (a normal territorial response) and soon got entangled in the hair. Salim Ali then caught the bird and let it go after placing an identity *ring* around its leg. This bird which breeds in Siberia spends a few months in Bombay. For several years the same bird appeared in Salim Ali's lawn in April and departed again in September for Siberia. No wonder, Salim Ali was hooked on to birds!



Salim Ali became a legend in his own lifetime, not only in India, but amongst students of birds and lovers of nature the world over. He received numerous awards – the Union Medal of the British Ornithologist's Union (1967), Phillips Medal from the World Conservation Union (1969), Padma Vibhushan (1976) and the Paul Getty Wildlife Conservation Prize of the WWF (1976). He received three honorary doctorates and was nominated to the Rajya Sabha in 1985. Dr. Salim Ali died in 1987, after a long battle with prostate cancer. In 1990, the Salim Ali Centre for Ornithology and Natural History was established in Coimbatore.

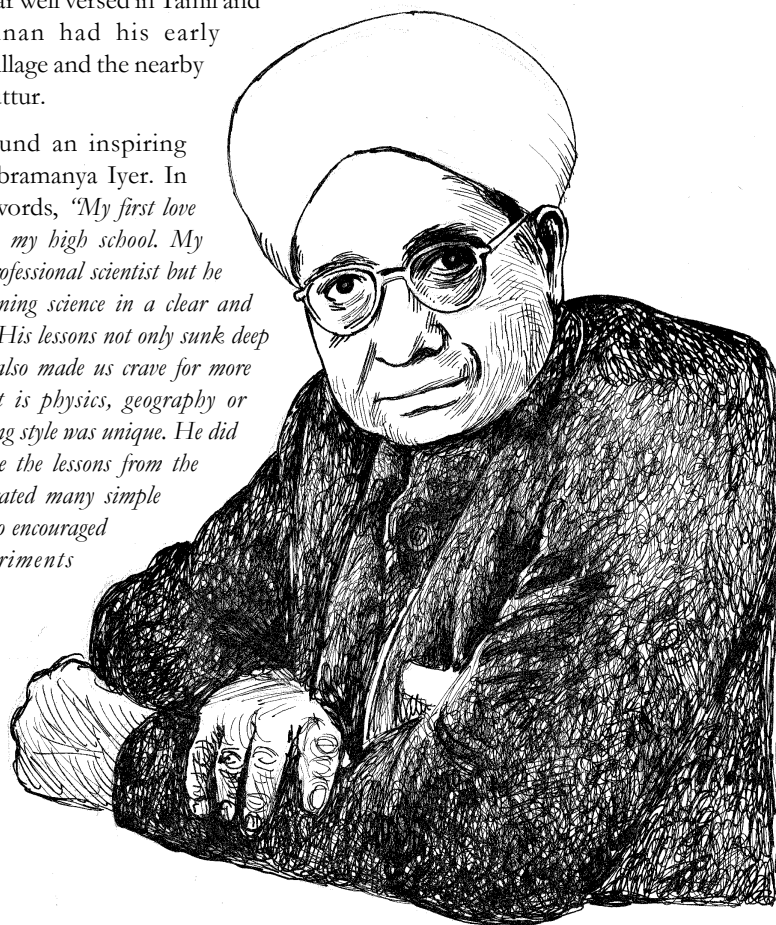






Kariamanikkam Srinivasa Krishnan (KSS for short) was born on 4 December 1898 in the village of Watrap in the Tirunelveli district of Tamil Nadu. His father was a scholar well versed in Tamil and Sanskrit. Krishnan had his early schooling in his village and the nearby town of Srivilliputtur.

In school he found an inspiring teacher in Sri Subramanya Iyer. In Krishnan's own words, "My first love for science came in my high school. My teacher was not a professional scientist but he was good at explaining science in a clear and captivating fashion. His lessons not only sunk deep into our mind but also made us crave for more science. Whether it is physics, geography or chemistry, his teaching style was unique. He did not simply reproduce the lessons from the book. He demonstrated many simple experiments and also encouraged us to do experiments ourselves."



In school he was once asked to write an essay on the Archimedes principle. In his assignment Krishnan also added an instrument he had constructed, on his own, for measuring density. Later he was surprised to find that the same instrument had been invented years earlier and was called the *Nicholas Hydrometer*. This was perhaps his first brush with independent research.

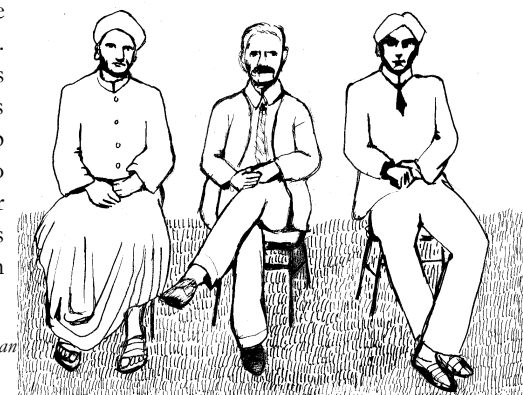
Krishnan attended the American College, Madurai (1914-1916) and later the Madras Christian College where he distinguished himself as a meritorious student by winning the Aberdeen Prize for Physical Sciences in 1918.

For the next two years Krishnan served as a Demonstrator in Chemistry in the Madras Christian College. Here he organized informal lunch-hour discussions where the students were free to discuss any question in physics, mathematics or chemistry. These seminars became so popular that many students from nearby colleges attended them too.

In 1920, Krishnan's name was recommended and he was to join the Solar Physics Observatory at Kodaikanal but by some quirk of fate it fell through. In retrospect it can only be seen as a big gain for physics.

Krishnan's heart lay in scientific research. In 1920, he enrolled in the MSc course at the University College of Science, Calcutta where Raman taught. After a good grounding in Physics he joined Raman as a full time researcher. His work in the laboratory began at 6 AM in the morning, often after an early walk and a cold water bath. He worked on the molecular scattering of light and X-rays in liquids. He also studied the magnetic anisotropy of gaseous molecules and crystals. But his interests were not confined to research alone. He avidly read books on literature, religion and philosophy.

In October 1928, Prof. Arnold Sommerfeld of Germany delivered a series of lectures on Quantum Mechanics at the Calcutta University. Krishnan carefully studied and collated the lectures into a booklet. Sommerfeld was impressed by Krishnan's originality and scholarship and even offered to publish the book under joint authorship. As was expected, Krishnan politely refused the offer.



Krishnan, Sommerfeld, and Raman

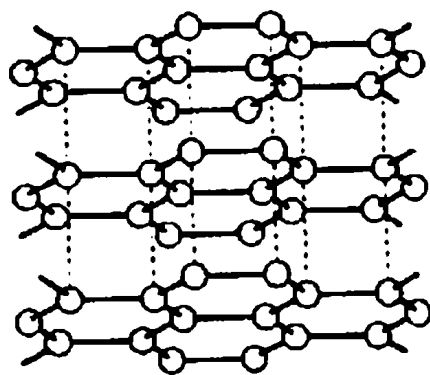
Krishnan's collaboration with Raman proved vital. At the instance of Raman he conducted experimental studies on the scattering of light in a large number of liquids, and its theoretical interpretations. He played a significant role in the discovery of *Raman Effect* for which the Nobel Prize was awarded in 1930. Raman himself generously acknowledged Krishnan's contribution to this momentous discovery. Though Krishnan played an important role in the discovery of the *Raman Effect* he did not pursue this subject later. He worked in the fields of magnetism, thermal conductivity and thermionics - a branch of electronics dealing with the emission of electrons from matter under the influence of heat.

In December 1928, Krishnan moved to Dacca University as a Reader in Physics. The department was then headed by the eminent physicist Prof. Satyendra Nath Bose. The congenial atmosphere delighted Krishnan and he worked with great enthusiasm. His low-cost, simple experimental procedures were jocularly described as *Sealing Wax and String* experiments by a foreign friend. He did extensive work on the magnetic properties of diamagnetic and paramagnetic crystals. In recognition of his contributions the Madras University conferred the DSc degree on him.

In 1933 Krishnan returned to Calcutta – the then scientific capital of India and took up the position of Mahendralal Sircar, Professor of Physics at the Indian Association for the Cultivation of Science.

Krishnan's investigations in light scattering and magnetic measurements were considered so profound that he was elected to the Fellowship of the Royal Society, London in 1940, at a relatively young age of 42.

The outbreak of war with Japan in December 1941 greatly disturbed life in Calcutta. There was the distinct possibility of academic institutions and research laboratories being closed down. So Krishnan accepted the offer of a Professorship in Allahabad University. Here he had to spend a considerable amount of time on administrative matters and hence his experimental work



The crystal structure of graphite, composed of carbon atoms linked by covalent bonds (indicated by solid lines), and weaker van der Waals bonds (dotted lines).

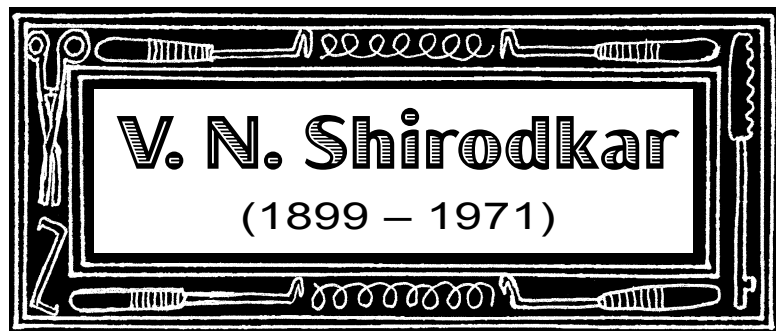
suffered. But as he was equally adept in theoretical work he soon turned his attention to developing a formula for the resistivity of metals and alloys. He was knighted in 1946. Just before India's independence he was invited to take up the position of the Director, National Physical Laboratory (NPL) at New Delhi.

In the late forties and early fifties Krishnan spent considerable time working with the Council of Scientific and Industrial Research, University Grants Commission, Atomic Energy Commission, and several other important government agencies. In 1954, he was awarded the Padma Bhushan and in 1957 the inaugural Shanti Swarup Bhatnagar Award.

In his personal life Krishnan combined deep scholarship of many disciplines with high human values of ethics and justice. He loved Sanskrit, Tamil literature and Carnatic music and had a marked sense of humour. Pandit Nehru once remarked that he had never met Krishnan without being told a new story! He played tennis and loved watching cricket. As one with a deep knowledge of science he was disturbed by its destructive capability and took active part in the peace movement.

During the construction phase of National Physical Laboratory, the contractor in his wisdom decided to cut down two problem trees near the entrance. Krishnan who was driving past was horrified and confronted the architect by asking, "Why are you cutting down these trees?" The architect replied, "Sir, we thought they looked asymmetrical in the landscape". Krishnan said, "You can still create symmetry. Not by cutting down a tree but by adding one more." Krishnan's deep sense of aesthetics and ethics is captured in this small vignette. When Prof. Krishnan died on June 13, 1961, he left behind his wife, two sons and four daughters, numerous colleagues and the whole nation to bemoan the loss.

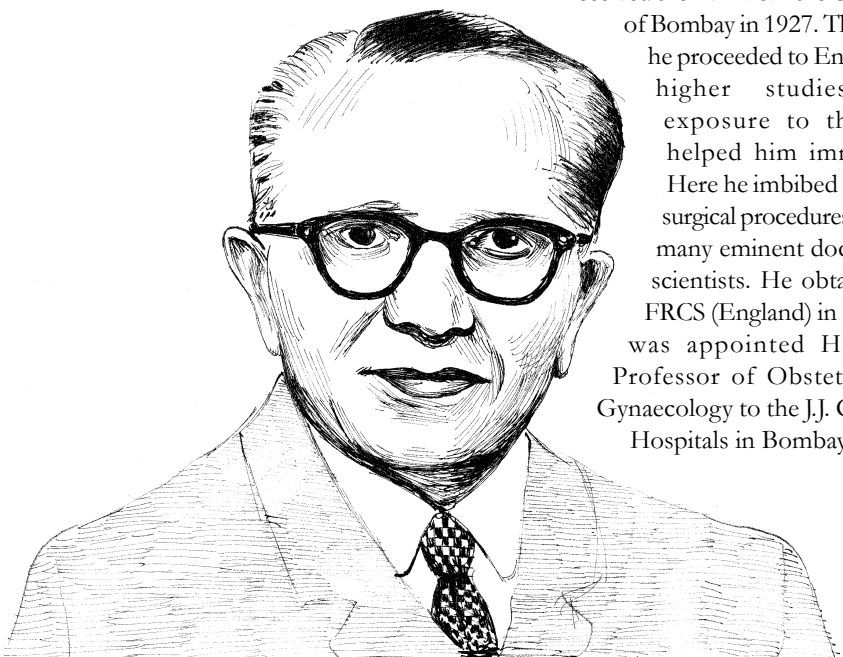




Dr. V. N. Shirodkar's name is famous the world over as the inventor of the *Shirodkar Stitch*. As a medical surgeon he made very important contributions in the field of women's diseases.

Vithal Nagesh Shirodkar was born in 1899 in the village of Shiroda in Goa from which his family derived its name. He was educated in Hubli and completed his medical training at the Grant Medical College in Bombay. He passed the final MBBS exam in 1923. He specialised in Obstetrics and Gynaecology and

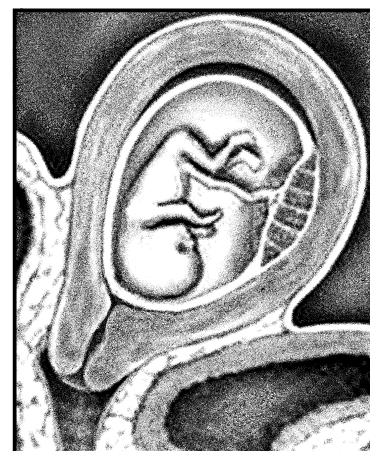
received the MD from the University of Bombay in 1927. There after he proceeded to England for higher studies. The exposure to the West helped him immensely. Here he imbibed the latest surgical procedures and met many eminent doctors and scientists. He obtained the FRCS (England) in 1931 and was appointed Honorary Professor of Obstetrics and Gynaecology to the J.J. Group of Hospitals in Bombay.



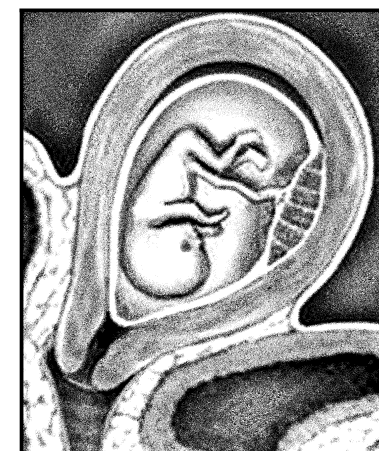
The J.J. Hospital is unique and probably one of the largest in the world with over 4,000 beds; 1,500 undergraduate and 650 postgraduate students. It is one of the oldest medical institutions of modern medicine in Asia and has a history stretching over 175 years. The legendary Robert Koch – who won the Nobel Prize for his pioneering research on tuberculosis, worked in this very institution at the turn of the century.

Shirodkar was appointed Honorary Professor of Midwifery and Gynaecology at the Grant Medical College in 1940. He was also attached to the Nowrosjee Wadia Maternity Hospital in 1941. He had a flourishing private practice – in which he catered to all segments of the society – both rich and poor. He worked 14 to 16 hours a day at his clinic in Cumballa Hill, Bombay. He rarely operated without an audience of keen observers. He gained international recognition and lectured widely, being one of the first to show films of his operations. He devised two operations for genital prolapse, and is reported to have done more tuboplasties than any other surgeon in the world!

In the 1950's spontaneous miscarriage during the second trimester was still a mystery. Many therapies were prescribed but none yielded satisfactory results. This relatively rare but distressing problem called for some refreshingly fresh insights. Professor Shirodkar was just the right person to look at this problem critically. He studied the cervix in non-pregnant and pregnant states and tried to understand the changes in anatomy and physiology. He was particularly interested in the changing nature of the cervix in normal pregnancy from a fibrous one to a dynamic muscular organ. His answer to the problem of habitual abortion was a surgery which put him and India firmly on the world map of operative Obstetrics and Gynaecology.

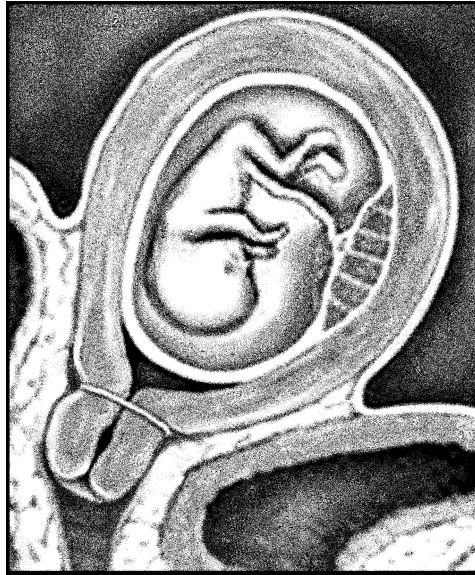


The muscular cervix is closed in a normal uterus.



In an incompetent uterus, the cervix is open.

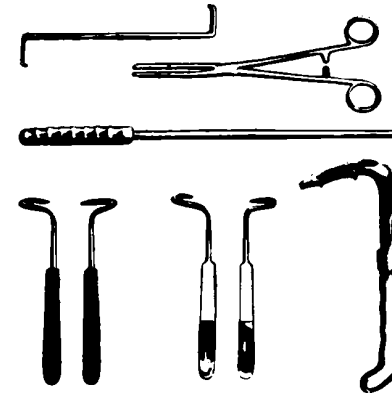
In 1955, Dr. Shirodkar described the cervical cerclage operation, a surgery which has stood the greatest test of all – time. He designed special instruments for the repair of the incompetent cervix. There have been a number of modifications but the original surgery still remains a masterpiece. He described his operation at an international seminar in Paris in 1951 and in Naples in 1956. The Italian connection was, of course, strengthened by the fact that a Hollywood star was also successfully operated by the same technique. He was astute enough to realize that his operation was not a panacea for all habitual abortions. He clearly laid out the conditions where the operation was most likely to be useful and where it would not work.



*The Shirodkar stitch keeps the cervix closed so that the pregnancy in an incompetent uterus can continue for the full term.*

The operation and the thought behind it probably came from Dr. Shirodkar's keen sense of questioning everything that was routine. He wrote in the preface to his monograph, *"With all due respects to the old masters, I did not reconcile myself to some of the operative procedures which fell far short of the ideal; ideas came to my mind for improving the time-honoured methods."*

At the Silver Jubilee Celebration of the French Society of Gynaecology in June 1951, Professor Shirodkar showed a film demonstrating an operation to place a ligature comprising three strands of catgut around the cervix. Shirodkar soon found that catgut was inadequate because of its solubility. He modified his technique by using a strip of *fascia lata* from the thigh and linen sutures for the treatment of habitual abortion in the second trimester. This is now universally called the *Shirodkar Operation* for which posterity will always remember him.



*These are some of the tools that Dr. Shirodkar invented for his surgery.*

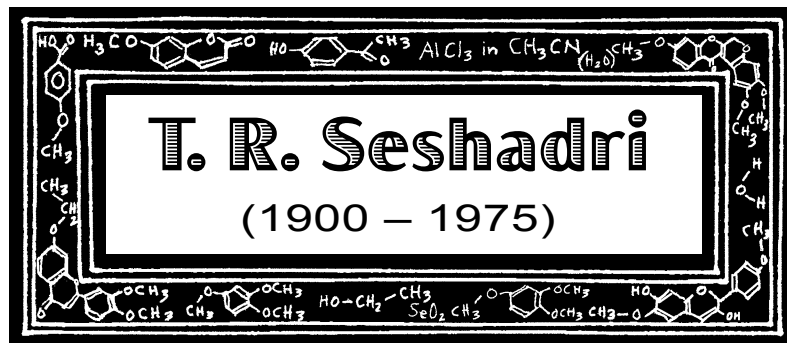
Shirodkar wrote numerous papers for medical journals. In 1960, he published *Contributions to Obstetrics and Gynaecology* based on his personal experience. He contributed a chapter on *Incompetent Cervix* in Volumes IV and V of *Progress in Gynaecology* by Meigs and Sturgis in 1963 and 1970. His views on genital prolapse found expression in the chapter entitled *A New Approach to the Understanding of the Anatomy and Treatment of Uterine Prolapse* in *Advances in Obstetrics and Gynaecology* by Marcus and Marcus in 1967. He wrote about his technique of placing a vaginal hood over the cervix as a

method of contraception or sterilization.

Professor Shirodkar died in Bombay on March 7, 1971. Dr. Shirodkar's mother died of cervical cancer. This inspired Dr. Shirodkar's son Manohar Shirodkar to spend his career studying the viral causes of the illness. Initially he worked at the John Hopkins School of Public Health studying the *Rous sarcoma* virus, the first virus discovered to cause solid cancer. He subsequently worked at The Virus Research Centre of the Rockefeller Foundation in Pune, India.

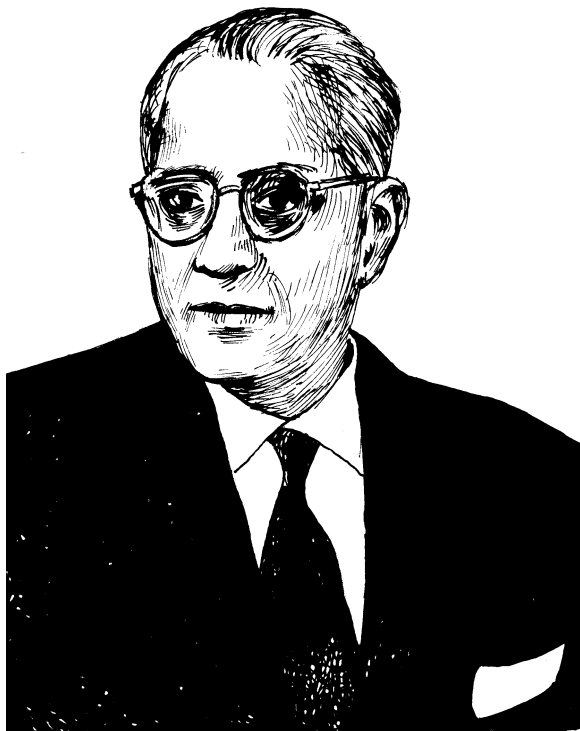
As a young man, Manohar Shirodkar turned away from a career as a clinician, yet he always admired his eminent father. In 1976, Manohar and his wife, Sudha, founded the Dr. V.N. Shirodkar Memorial Research Foundation, an organization that embodied the dreams of both Manohar Shirodkar and his father. The organization screens underprivileged women for cervical cancer and investigates novel antiviral biological agents to treat virus diseases.

Besides being a busy practitioner Professor V. N. Shirodkar published widely and took a keen interest in social medicine. He was a member of the Shantilal Shah Committee on abortions and also established the Family Planning Association in India. In 1971, the Government of India honoured him with the Padma Vibhushan award.



*"Money and materials alone do not secure good research, they are only adjuncts and it is the human element behind them that matters."*  
 – T. R. Seshadri

T. R. Seshadri was born on 3 February 1900 in Kulitalai, a small town situated on the banks of the river Kaveri in Tiruchirapalli. His father T. Iyengar was a teacher in a local school. Seshadri went to school in the temple town of Srirangam and Tiruchirapalli. His teachers instilled in him a sense of duty, obligation to society, love of humanity and thirst for knowledge. In 1917, Seshadri joined the Presidency College, Madras to do BSc chemistry. While studying at college he stayed at Sri Ramakrishna Mission's student's home. The spiritual values he learnt from the Mission Monks remained with him throughout his life. At Presidency College he was



taught by B. B. Dey and P. Narayana Iyer, whom he revered and remembered for the rest of his life. After finishing BSc he worked for a year with the Ramakrishna Mission. Later he joined the Chemistry Department of the Presidency College as a researcher. His outstanding work on chemical synthesis won him two prizes from the University of Madras – the Sir William Wedderburn Prize and the Curzon Prize.

In 1927, Seshadri was selected for a scholarship awarded by the Government of Madras for higher studies in England. Here at the Manchester University he worked under Prof. Robert Robinson, FRS a very distinguished organic chemist, who later became the President of the Royal Society and also received the Nobel Prize. Seshadri did pioneering work on new anti-malarial drugs and synthesis of compounds. Based on his research the Manchester University awarded him a PhD in 1929. Working with Prof. Robinson was cherished by Seshadri as the most important event in his research career.

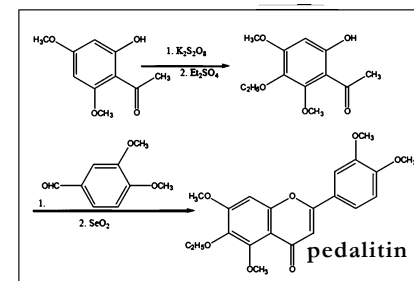


After his PhD, Seshadri worked for a few months in Austria with Nobel Laureate Prof. Fritz Pregl, famous for his work on organic micro-analysis. He also worked with Prof. George Barger, FRS at the Department of Medical Chemistry of the University of Edinburgh. In 1930, Seshadri returned to India.

In 1934, he joined the Andhra University, Waltair as Reader and Head of the Department of Chemistry. Here he worked hard, built new laboratories, framed new courses and established an active research school. The University entrusted upon him the additional responsibility of setting up new Departments of Chemical Technology and Pharmaceutical Chemistry. All this while he pursued his own research and could be seen bicycling to the Biochemistry Department of the Andhra Medical College located 5 km away at Vishakhapatnam. His devotion to work inspired many young students to take up research and make

it their life long profession. Soon Andhra University became the most active centre for original chemical research in the country.

The Second World War disrupted Seshadri's work. Chemicals and equipment which came from Europe were difficult to get. Also, the army took over the chemistry



*Seshadri developed a way to synthesize pedalitin, a flavanoid found in sesame.*

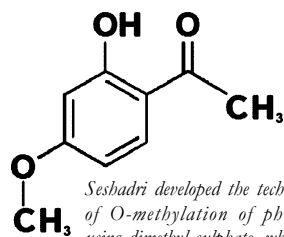
department building at Waltair. Seshadri had to move first to Guntur and then to Madras but all this while he continued with his research. After the war the labs at Waltair were rebuilt and Seshadri returned.

In 1949, Seshadri was invited to head the Chemistry Department of the Delhi University by its Vice Chancellor Sir Maurice Gwyer. Seshadri took up the challenge and established from scratch, in a very short period of time, a research school in the chemistry of natural products comparable to the best anywhere in the world. Students from all over the country and in later years from other parts of the world came to work under his guidance. His large research team included postdoctoral scholars from England, France and Germany. He trained over 160 PhD students and published more than 1000 papers. A good number of his students occupy senior positions both in India and abroad in teaching and research establishments. He authored the book titled *Chemistry of Vitamins and Hormones*. On attaining the age of superannuation in 1965 he was appointed as the first Emeritus Professor of the University.

Seshadri had a particular attraction for the variety and range of floral and animal colouration. His early work was on the pigments of the cotton flower and on different species of the hibiscus. Apart from explaining the structure of new compounds he evolved new procedures that have now become routine in the study of chemistry. He was fascinated by biosynthesis and did pioneering work in this field. He was the first Indian to initiate chemical studies on lichens from the Himalayas.

Professor Seshadri's expert advice and mature wisdom were frequently sought by a large number of organisations – CSIR, ICMR, ICAR and DAE. He headed several expert committees dealing with education, health, science, agriculture and defence. He was also a member of the scientific advisory

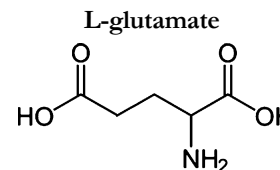
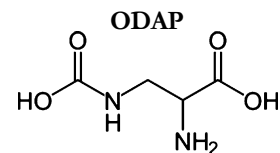
committee to the Cabinet and UNESCO. He received numerous honours and awards. Seshadri was elected a Fellow of the Royal Society in 1961 and conferred honorary doctorate degrees by several Universities. He was the general president of the Indian Science Congress and the president of the Indian National Science Academy. He was on the editorial boards of the international journals – *Tetrahedron* and *Phytochemistry*. The Government of India conferred on him the Padma Bhushan in 1963.



Seshadri developed the technique of O-methylation of phenols using dimethyl sulphate, which is now widely used. Here is a compound that can be synthesized using this technique: 2-hydroxy-4-methoxyacetophenone.



Seshadri did research on the toxin in the pulse, khesari (*Lathyrus sativus*). Khesari contains varying amounts of the neurotoxin, ODAP, which can cause paralysis in humans and cattle, if taken in large quantities. The toxicity of ODAP is thought to be because of its structural similarity to the neurotransmitter, L-glutamate.



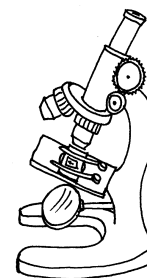
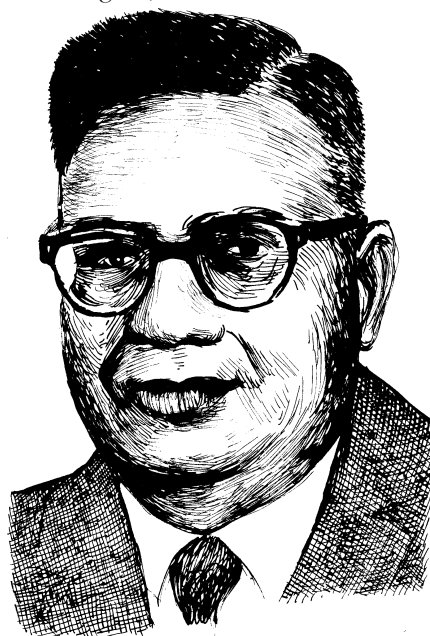
Prof. Seshadri rose to his eminent position by virtue of his deep devotion to duty. However, the one thing that he cherished most was the affection of his students. He helped them in every way possible including giving financial assistance in times of need. To remain with his students he declined the post of the Chairman of the University Grants Commission. His students showered their love on him by bringing out commemoration volumes on his 60th, 65th, 70th and 75th birthday. They also set endowments to perpetuate his memory. Even after retirement Seshadri continued to teach and guide research students and was always available to them. His research school in Delhi consisted of half a dozen laboratories in three different buildings in which more than 25 students worked at a time. He found time to visit them at least four times a day and discussed their problems. He hoped that chemistry would secure for him the resources to live a simple life. In 1965, he donated his entire personal library to the Delhi University's Department of Chemistry. He thought of working peacefully in the Department till the end of his life. However, the new University rules promulgated in 1972 prevented him from receiving any remuneration whatsoever. This brought financial ruin... He was left with no research grant or means of subsistence... Thus ended the life of this great son of India on 27 September 1975.



Prof. Panchanan Maheshwari was a legendary scientist who did India proud by placing it on the world botanical map. He was born in Jaipur on 9 November 1904. The word *Panchanan* in Sanskrit means an intellect of *five faces* or people. The appropriateness of the name soon became apparent. His father was a clerk but struggled hard to give his son the best possible education. Panchanan went to school in Jaipur and cleared Matriculation at the age of 13. Because of his weak eyesight he could not take up medicine, but nevertheless he pursued a career in science.

For BSc (1923) he studied at the Ewing Christian College - affiliated to the Allahabad University. Here Maheshwari came under the spell of a remarkable American Missionary teacher, Winfield Scott Dudgeon, a renowned American

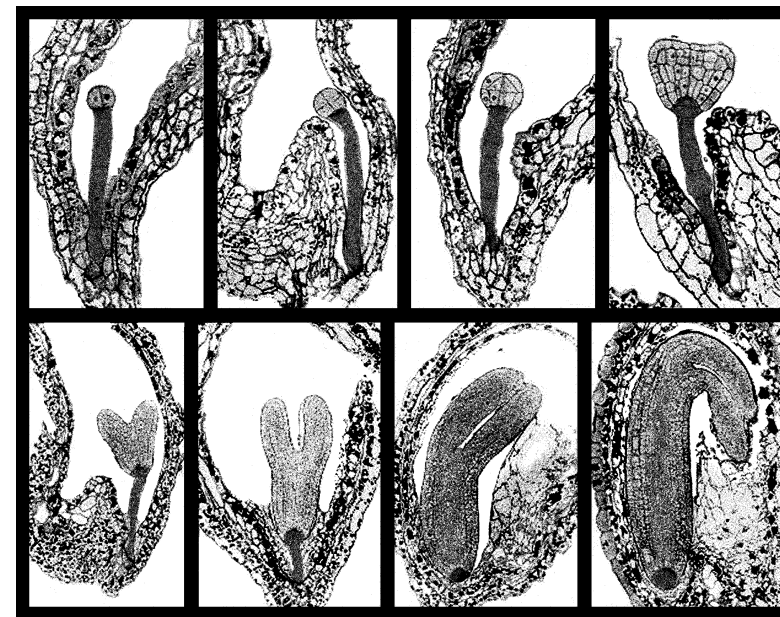
botanist and founder-President of the Indian Botanical Society. Although students revered him, he was also feared as a hard taskmaster. But in Maheshwari, Dudgeon found a student he had long been looking for. Dudgeon took the young Maheshwari on expeditions to collect botanical specimens and taught him the basic techniques of plant morphology. On one occasion Dudgeon told Maheshwari, "*A Hindu father believes his life's aim is fulfilled if he has given his son a good education. My son is dead, but I wish to leave behind at least one student who will carry on my mission.*"



Young Maheshwari was exceptional in studies. He did MSc (1927) and DSc (1931) under Dudgeon's guidance. He studied the morphology, anatomy and embryology of angiosperms - the class of plants which produce flowers. After completing his studies Maheshwari went to his mentor to offer him *guru dakshina*. Quick came the reply, "*Do for your students what I have done for you.*" This message the young man took to heart. Wherever he went thereafter, whether it was Agra, Dacca or Delhi, he tried to do just that.

After joining Agra College in 1931 he immediately set up a school of plant embryology. With meagre resources he acquired a microscope and a microtome. At home his unschooled wife Shanti assisted him in preparing professional slides!

We know that ovules in the flower of a plant fertilize when an insect or wind brings to it pollen from another plant. This occurs in a cavity inside the flower called 'ovary' and an embryo is the result. The embryo, the unborn baby plant, gets nutrition and food from the surrounding soil and grows up to become a plant. The way the embryo grows up to become a full-fledged plant differs from species to species. Maheshwari studied this process of growth in several



This sequence of micrographs (not to scale) shows the growth of an embryo of *Arabidopsis*, from the mustard family.



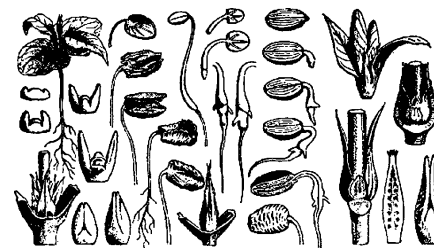
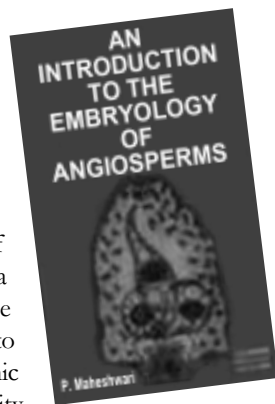
species of angiosperms. He also classified them according to the differences he found in such embryological studies.

In 1936-37 Maheshwari went to Europe and England during which he made many valuable contacts. On returning he worked in Lucknow for a while with the famous palaeobotanist Prof. Birbal Sahni. In 1939 he joined the Dacca University to start a new biology department. There he met many illustrious scientists – Satyendra Nath Bose and Meghnad Saha. He worked in Dacca University for 10 years and established a flourishing school of botany. After partition in 1947 he was requested by authorities in East Pakistan to continue, but just then an irresistible invitation came his way.

In 1949, he was invited by Sir Maurice Gwyer Vice- Chancellor of Delhi University (also the last British Chief-Justice of India) to head the new Department of Botany. This was the most creative and productive period of his career. In the 1950's he was already a name to reckon with. He had amazing personal qualities and a photographic memory. He was forthright, unconventional and had boundless energy. He was an outstanding scholar and teacher whose motto was *Work is worship*. As a perfectionist he set high standards for himself and accepted nothing that was second-rate. His promptness and punctuality were proverbial.

He inspired students to carry out research with low-cost, improvised apparatus. His efforts slowly bore fruit. Soon his department developed and gained recognition abroad. Moreover, several scientists elsewhere became interested and started research in embryology. Maheshwari can well be called the father of modern embryology.

Maheshwari invented the technique of test-tube fertilization of angiosperms. Till then no one thought that flowering plants could be fertilized in test-tubes. This technique accelerated the rate of fertilization by eliminating the dormancy period of a seed. Many more flowering plants could now be crossbred. This technique proved of immense help to plant breeders and opened up new avenues in economic and applied botany. Soon after joining Delhi University he wrote a book *An Introduction to the Embryology of Angiosperms*. This book, considered a classic, has been translated into several languages including Russian. It continues to be cited even 50 years after its publication!



detected and corrected many dubious errors. *An illustrated Flora of Delhi* was written under his supervision. This remains an authoritative field-guide for laymen and professionals alike for over half a century.

In 1951, he launched the International Society of Plant Morphologists with the journal named *Phytomorphology*. To foster writing skills amongst the undergraduates, he started *The Botanica*, published by the Delhi University Botanical Society. This magazine was an instant success

as it carried lively and informative articles. At the request of the NCERT, he prepared a textbook of biology for higher secondary schools. It contained numerous inspiring examples of the rich Indian flora. Many educationists think this to be Maheshwari's most enduring and seminal contribution.

In class Maheshwari was like his guru, Dudgeon. His students both loved and feared him. They named many newly discovered species of plants in his honour, like *Panchanania jaipuriensis* and *Isoetes panchananii*. Maheshwari was alone in crusading against Stalin's favourite scientist Trofim Lysenko – a Russian plant breeder who fraudulently advocated the inheritance of acquired characters.

Panchanan Maheshwari was a scientific citizen of the world and many academies felt honoured to make him a Foundation Fellow. In 1934 he became a fellow of the Indian Academy of Sciences, Bangalore. The Indian Botanical Society honoured him with the Birbal Sahni Medal in 1958. He was the General President-elect of the Indian Science Congress Association for 1968, a role he could not fulfil on account of his untimely death on 18 May 1966. He was elected Fellow of the Royal Society in 1966. It was typical of him that he did not disclose this even to his family members. They learnt it later only through newspapers.

Maheshwari wrote popular science articles on Plant Power to attract the young. For instance, he wrote that Gandhi's very first Satyagraha had to do with the plant *Indigofera tinctoria*, a source of the indigo dye used in textile manufacture.



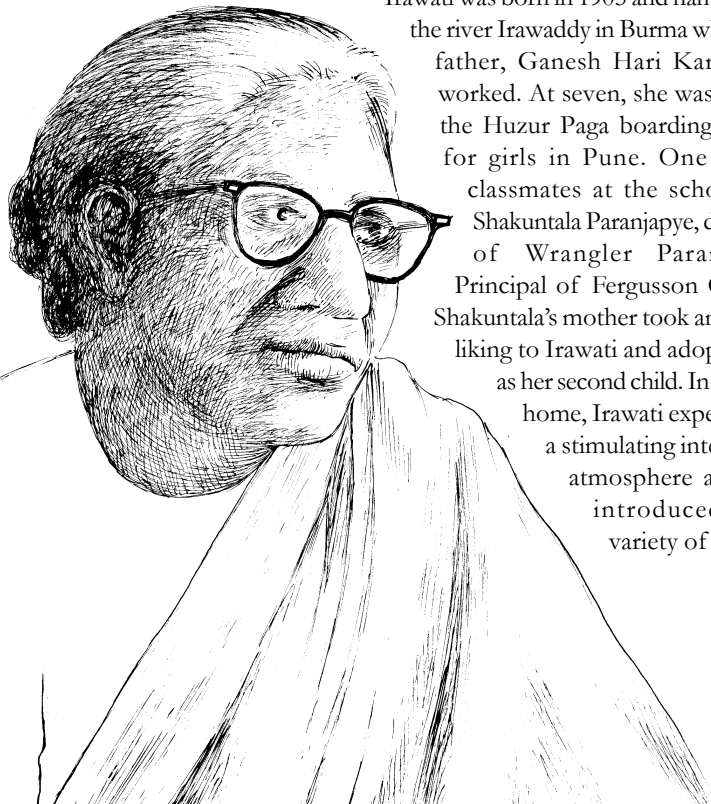


# Irawati Karve

(1905 - 1970)

Irawati Karve was India's first woman anthropologist. She took up this subject when it was still in its infancy. She was a pioneer and the first to teach this subject in the Poona University. She was also an Indologist, a collector of folk songs and a translator of feminist poems. She radically reinterpreted the Mahabharata in her book *Yugant*, thus transforming her readers' understanding of the epic.

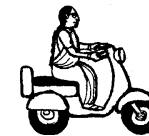
Irawati was born in 1905 and named after the river Irawaddy in Burma where her father, Ganesh Hari Karmarkar worked. At seven, she was sent to the Huzur Paga boarding school for girls in Pune. One of her classmates at the school was Shakuntala Paranjapye, daughter of Wrangler Paranjapye, Principal of Fergusson College. Shakuntala's mother took an instant liking to Irawati and adopted her as her second child. In her new home, Irawati experienced a stimulating intellectual atmosphere and was introduced to a variety of books.



Irawati studied Philosophy at the Fergusson College, graduating in 1926. She then got the Dakshina Fellowship to work under G. S. Ghurye, the head of the Department of Sociology at Bombay University. In the meantime, she got married to the chemist Dinkar Dhondo Karve – son of the great social reformer Maharishi Karve – pioneer of widow remarriage and women's education in Maharashtra.

Getting married into a 'progressive' family did not prove advantageous. For, while Maharishi Karve encouraged women in public, this liberalism did not extend to his own family. Karve opposed Irawati's attempts to go to Germany for higher studies. Often reformers and revolutionaries are hardest on those closest to them!

Despite opposition in 1928, Irawati went to the Kaiser Wilhelm Institute for Anthropology to do her PhD. Her thesis topic was: *The normal asymmetry of the human skull*. Irawati and her husband realized early that they were not cut out for social reform work. So, they both stuck to research and teaching. Dinkar taught chemistry and later became the Principal of the Fergusson College. Dinkar recognized the exceptional intellectual abilities of his wife and solidly stood behind her. He took on household responsibilities so that Irawati could pursue her research. He ensured that there was always petrol in her scooter and money in her purse!



Irawati was the first woman in Pune to ride a scooter! She refused to apply *kumkum* or wear a *mangalsutra*. But despite her disregard for convention, Irawati essentially led a middle class Hindu life. She learnt Sanskrit in school, as all educated children did in those days. Her father gifted her 18 volumes of *Mahabharata* in Sanskrit published by the Bhandarkar Oriental Research Institute. She loved and cherished this gift. Later she wrote *Yugant* – based on the *Mahabharata*. This book won the literary prize from the Sahitya Akademi for the best book in Marathi in 1967. In this book the super human characters of *Mahabharata* venerated for centuries by Indians have been subjected to devastating scrutiny.



After returning from Germany, Irawati worked for a while as Registrar at the SNDT Women's University in Bombay (1931-36). In 1939, she joined the newly revived Deccan College, Pune as Reader in Sociology, and worked there for the rest of her life. For a while, she was the only sociologist at the Deccan College, which meant that she had to teach all the papers in the subject. This put a heavy burden on her.

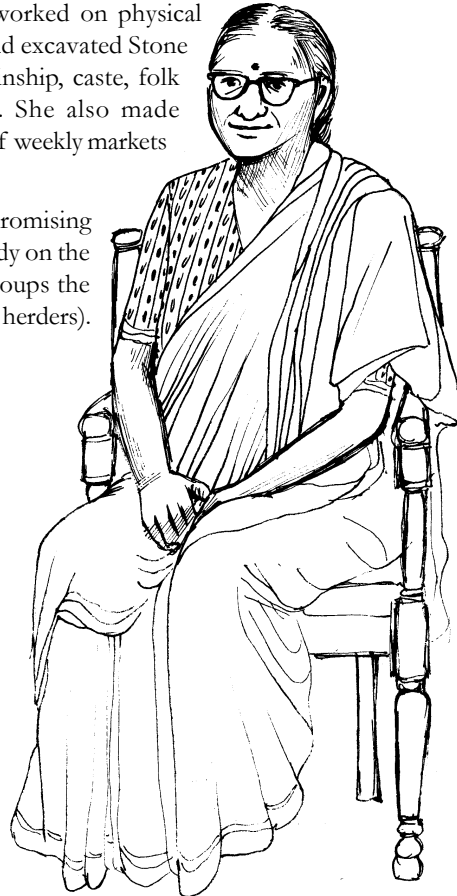
Irawati was influenced in her work by her MA supervisor G. S. Ghurye – they shared a common belief in the importance of family, kinship, caste and religion as the basis of Indian society. She was interested in surveys of castes and tribes in order to piece together a more comprehensive picture of society. Irawati was inherently curious and was passionate about doing field work in new areas of research – like archaeological explorations.

Irawati authored a total of 102 articles and books in English. She also wrote eight books in Marathi. Not only is the range remarkable, but it is quite unique among her contemporaries. She worked on physical anthropology and archaeology – and excavated Stone Age skeletons. She documented kinship, caste, folk songs, epics and oral traditions. She also made landmark socio-economic surveys of weekly markets and dam displaced people.

Later K. C. Malhotra – her most promising student conducted a pioneering study on the human ecology of two nomadic groups the *Dhangars* and *Nandivalas* (both cattle herders).

Doing fieldwork for a woman in those days was not easy. In Irawati Karve's own words:

*"I travelled from place to place never knowing where my next step was to be nor where my next meal was to come from.... Rest pauses between work, meal times, and travel in buses full of people and in third class railway compartments filled with men and women ..."*



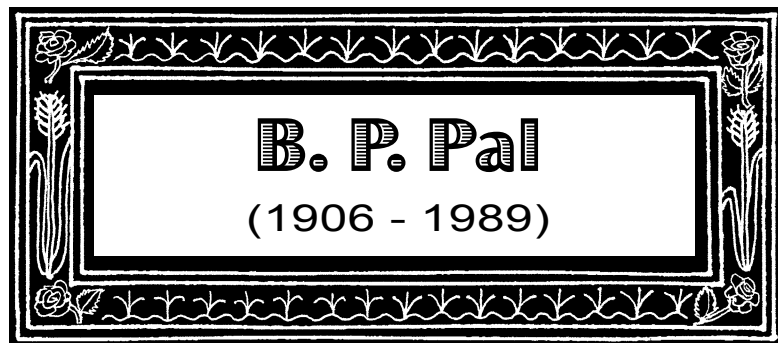
H. D. Sankalia - the eminent archaeologist recalled an incident when he and Karve were doing fieldwork. Nobody from the village would feed them since one of their workers was a 'semi-untouchable' and Irawati ended up cooking at the end of a long day's work. She spent most vacations travelling, while the children stayed home waiting to see the new curiosity she brought with her and hear her latest stories. Sometimes they accompanied her on her trips - Jai to Malabar, Bihar and Orissa, and her son, Anand to Coorg, to measure *Beta Kurubas* and *Jena Kurubas*.

Once she walked for hours up and down the Mula-Mutha River in Pune searching for Stone Age tools. In another expedition she had to sleep in a truck because she could not find a room.

Her literary writings in Marathi were examples of a delicate balance between one who was involved but still detached. She wrote with a sociologist's insight and a writer's eye and what emerged were flashes of rare insight, vivid portraits of 'culture'. One famous example is her essay on the Pandharpur pilgrimage, translated into English as *On the road*. She was one of those responsible for reviving the genre of 'personal essays'.

Irawati Karve widened our understanding of the relation between the present and the past. She was equally aware of the problems and importance of nation building in a multi-cultural, multi-religious, and a multi-lingual state. Her survey of the people displaced through the Koyna Dam holds enormous contemporary relevance when millions are being ousted by mega projects. She wrote sensitively from a women's perspective of what women like Kunti and Draupadi must have felt in the epic *Mahabharata*. Indeed, her pioneering work on kinship and family laid the foundation for future research in several other areas - especially in the field of women's studies.





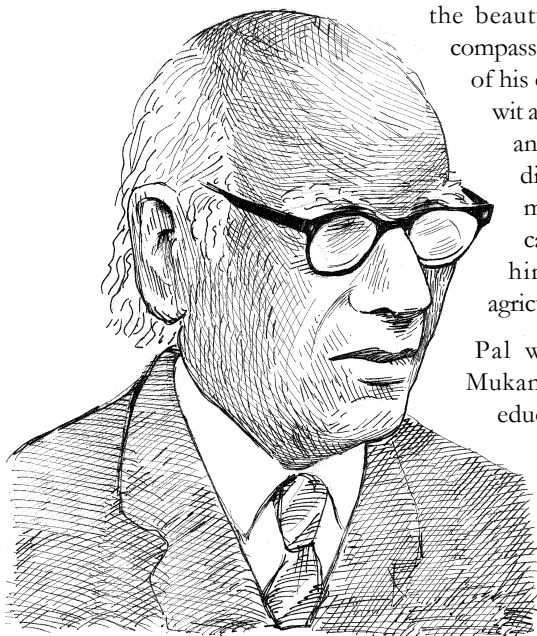
*"It was during Dr Pal's leadership that the agronomic research on wheat in India equalled the best in the world. He was truly the architect of India's Green Revolution."*

*- Dr Norman Borlaug, Nobel Laureate*

Benjamin Peary Pal was not only a gifted plant breeder and geneticist but was endowed with amazing human qualities. As a bright scientist he grasped the critical issues which hampered Indian agriculture. He was deeply sensitive to

the beauty and harmony in nature. As a compassionate warm person he was a darling of his colleagues and a profound store of wit and wisdom. His interests were wide and varied. He was a painter of rare distinction and a lover of classical music, both Indian and Western. His catholicity of interests certainly made him the *Homi Bhabha* of Indian agriculture.

Pal was born on 26 May 1906 in Mukandpur, Punjab. He had his early education in Burma where his father worked as a Medical Officer. There he attended the St. Michael's School, where he developed his love for roses and painting. His school had a beautiful rose garden and many of his teachers were



fond of gardening and painting. He always stood first in the class and once won a paint box as a prize. This perhaps led to a life long passion with painting.



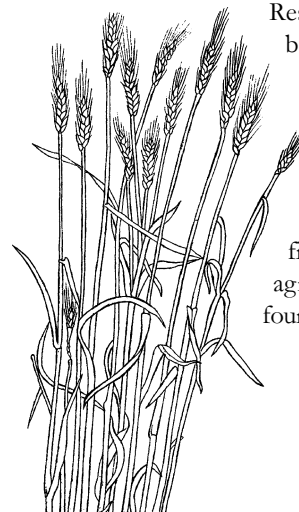
He finished MSc Botany in 1929 winning the Matthew Hunter Prize for topping all science streams in the University. He then proceeded to Cambridge, UK, where he did a PhD in 1933. His PhD thesis under the guidance of Sir Roland Biffen and Sir Frank Engledow is still a classic - amongst the first to exploit the potential of wheat hybrids. He joined the Indian (then Imperial) Agricultural Research Institute (IARI) in Pusa, Bihar in 1933 and rose to become the Imperial Economic Botanist in 1937. In 1936 after an earthquake severely damaged the Pusa institute it was shifted and Pal came to New Delhi.

Dr. Pal's enormous contributions to Indian agriculture can only be gauged by recalling the grim food scenario of the late 1960s. India faced a major food crisis and was viewed as a country of starving people. Millions of our people survived on food gifted by the USA under the PL-480 plan. The Green Revolution conceptualised and launched under Pal's leadership radically transformed India from a starving to a surplus nation.

Pal's contributions can be classified into five major categories – research, education, extension, institution building and international cooperation. In all these areas his work was marked by tireless striving for relevance and excellence.

Pal's contribution to research relates to the breeding of multiple-resistant varieties of wheat. He understood that agricultural productivity could only be advanced in a sustainable manner through biological diversity. To systematically search for new genes he established the Plant Introduction Division which subsequently became the National Bureau of Plant Genetic Resources (NBPGR). He introduced modern technology to breed new varieties of potato, tomato and tobacco. For this he scouted for the best scientific talents in different institutes and actively collaborated with them.

He realized that a country the size of India with agriculture as its mainstay would require a huge army of high quality scholars in this field. This was the only way to uplift Indian agriculture. To achieve this end in 1958, he founded the Post-Graduate School at IARI, which



was soon conferred the status of a deemed university by the UGC. The contributions of over 4000 MSc and PhD scholars from this institute have fed India's billions and made the country self-sufficient in food.

Pal realized that only outstanding basic research could drive and sustain applied research. For this he established the School of Fundamental Genetics in IARI. He also set up mechanisms to foster multidisciplinary, multi-institutional research to solve problems of applied research. As Director of the IARI he made distinguished contributions to research, education and extension.

He served as the Director General of the Indian Council for Agricultural Research ICAR (1965-72). It is during this period that high-yielding varieties of wheat, rice, sorghum and maize became available for wide spread cultivation. To give further boost to the Green Revolution he strengthened research in the areas of animal husbandry and fisheries. This was also the phase when India collaborated with the best in the world to increase its farm productivity - with Mexico for wheat and Philippines for rice. Pal's efforts raised the stature of agriculture both nationally and internationally.



"Solve problems in the field" was his mantra for applied research workers. "From the lab to the field," was another motto for which Pal strove hard. He was convinced that in the final analysis it was the farmer who was the ultimate judge of applied research. To enable the students to appreciate the complexities of Indian society Pal introduced many social science courses in both IARI and ICAR. The reorganised ICAR model was soon emulated by several developing countries like Pakistan, Bangladesh, Philippines and Nigeria.

After retirement from the ICAR, Pal concentrated his energies on protecting the environment and became the first chairperson of the National Committee on Environmental Protection and Coordination. Pal was a rose breeder of distinction and created several new varieties. He was founder President of the *Rose Society* and *Bougainvillea Society*. With M. S. Randhawa he set up the



Chandigarh Rose Garden. His home was always open to all and he was a friend, philosopher and guide to both young and old research workers.

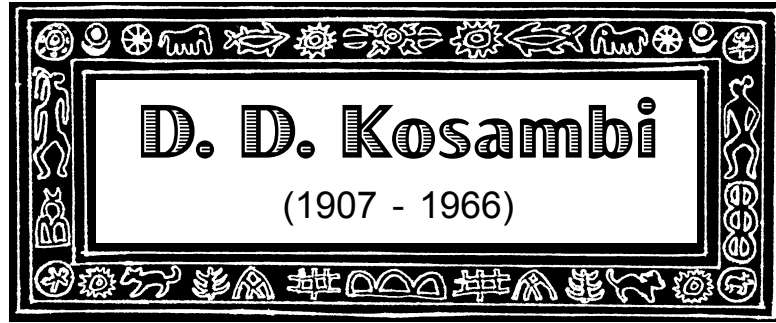
He founded the *Indian Society of Genetics and Plant Breeding* and edited the *Indian Journal of Genetics and Plant Breeding* for 25 years. He wrote many books to popularize his love for flowers. Notable amongst them are *The Rose in India*, *Beautiful Climbers of India*, *Flowering Shrubs* and *Environmental Conservation and Development*.

Pal was a trustee of several international research institutes and spent time strengthening agricultural research in many developing countries. The scientific respect he commanded is evident from his election not only as a Fellow of the Royal Society of London, but also of the science academies of France, Japan and the USSR, and of the Third World Academy of Sciences. In 1987, the Government of India conferred on him the Padma Vibhushan. In 2007, the Department of Posts printed a commemoration stamp of Pal with his beloved roses.

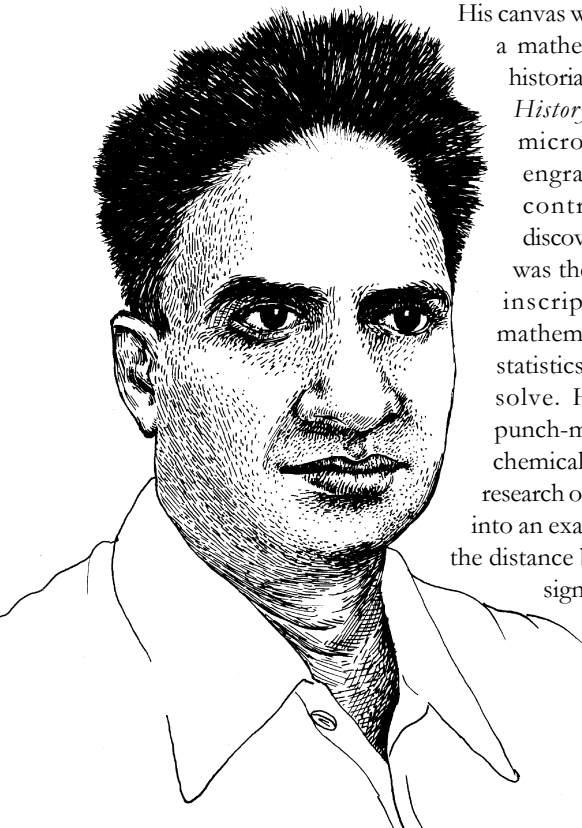


Pal was a gentle person and deep humanist. Many of the exquisite roses varieties bred by him were named to honour scientist like Sir C. V. Raman and Homi Bhabha. His first loved remained the IARI and towards the end he willed all his property including the two houses in New Delhi and Shimla, and his rare collection of roses and other articles to the IARI. Dr. Pal passed away in 1989.



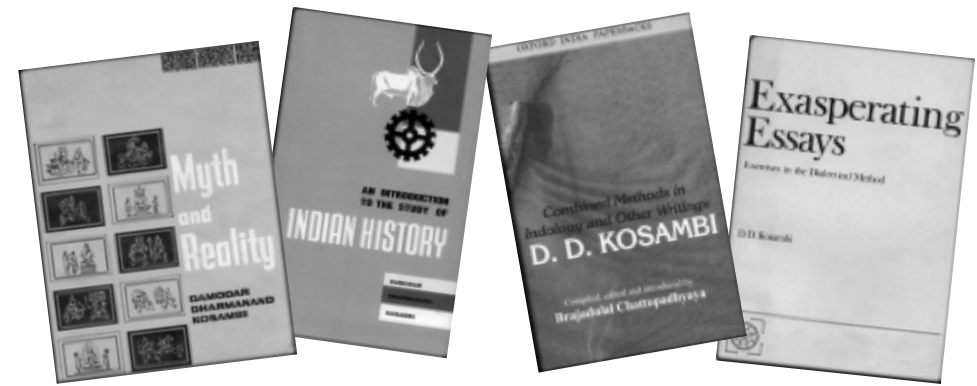


Professor D. D. Kosambi was endowed with a truly renaissance versatility. He was one of the few great Indians who had grasped the nature of twentieth century science and technology and its implications for humanity. Shunning the limelight of publicity, he made outstanding contributions to various fields of knowledge, which included Mathematics, Statistics, Numismatics, Indology, History as well as contemporary social problems. He devoted a great deal of his time to the *Peace Movement* and the campaign against nuclear weapons.



His canvas was indeed vast. Though qualified as a mathematician he showed professional historians original ways of looking at *Indian History*. With his large collection of microliths and megaliths with rock engravings he also made significant contributions to archaeology. He discovered several ancient trade routes and was the first one to decipher the Brahmi inscript at the Karle caves. As a mathematician, Kosambi taught himself statistics by selecting practical problems to solve. He weighed over 7,000 punch-marked coins precisely in a chemical balance. His painstaking research on coins raised numismatics into an exact science. His formula for finding the distance between chromosomes occupies a significant place in classical genetics.

Profound insight combined with an acute sense of detail,



complete grasp of the material under study, and creative use of the dialectical materialist method, enabled him to raise significant new questions and to offer original answers.

Within 5 years of its publication his book *An Introduction to the Study of Indian History* (1956) became mandatory reading for professors and students of Indian history all over the world. The book, together with two more that followed – *Myth and Reality* (1962) and *The Culture and Civilisation of Ancient India in Historical Outline* (1965) – have been translated into many languages of the world. His editions of the poetry of Bhartrihari and of the oldest known Sanskrit anthology - *Subhashitaratnakosha* - are acknowledged landmarks in Indian text-criticism.

Kosambi made singular contributions not just to the study of Indian History but to the evolution of its very methodology. He didn't believe that history dealt only with the dead past. He believed that history lived on in the present. And so in studying history Kosambi looked at how people lived today - what goods they used, what rituals they practised, what food they ate and the songs they sang. From that he established a continuum between the past and the present.



In the early 1990's a 13-part serial titled *INDIA INVENTED* based on Kosambi's perspective of looking at *Indian History* was made by the very well known activist and social scientist Arvind Narain Das. All these wonderful episodes can now be viewed on *Google Video*.

Damodar Dharmanand Kosambi was born on July 31, 1907. He spent his initial years in Goa speaking Konkani. His father, Acharya Dharmanand Kosambi was a renowned Buddhist scholar and taught Pali at the Fergusson College, Pune. So, Damodar had his early schooling in Pune. Acharya Dharmanand was a visiting faculty to Harvard University, where he worked on Pali Buddhist texts. In 1918, on his second visit to Harvard he

took along his oldest daughter, 19-year-old Manik and his 11-year-old son Damodar. By then Damodar was already known by his nickname *Baba*. He studied at the Cambridge Grammar School and later at the Cambridge Latin School. After four years, his father returned to India but Baba stayed behind to finish his schooling. Then he spent a year in India and tried to enrol in a college. But that proved difficult because of the different educational systems. So in 1926 Baba returned to the USA and enrolled himself at Harvard.

Damodar was a fitness freak. Regular exercises, swimming, rowing and hiking were his passions. He did brilliantly at Harvard, but during one semester along with three A's he also got one B grade. This upset his father. As a challenge, Baba did a summer course in Italian (which he had never studied before) and received an A+ which the instructor had not given anyone before. Baba promptly sent the note to his father without comment. Apart from shelves of books on many subjects and languages his room in Harvard had one photograph of Gandhiji.

He majored in mathematics and studied several European languages - Greek, Latin, French and German. He learnt Sanskrit, Brahmi and Prakrit too. The libraries in America exposed him to the wonders of all branches of knowledge from astronomy to the physical sciences, from plumbing the depths of the psyche to delving into the collective human past. Given his intellectual capacity and energy, Kosambi could have

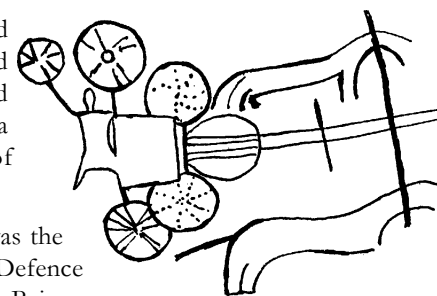
made his mark in any one of these branches of knowledge. But he chose mathematics because he *could not resist its fascination*. Mathematical results possessed clarity and were more intellectually satisfying than others.

Kosambi graduated from Harvard with high distinction (summa cum laude) in 1929. Because of the economic depression scholarships were difficult to get. So he returned to India. Thereafter he stayed close to his cultural roots in India.

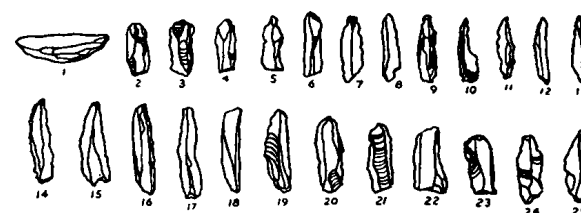
Kosambi taught mathematics all his life. He started with the Banaras Hindu University (1929-31). Here along with mathematics he also taught German which he believed to be the language of science. He also taught for a while at the Aligarh Muslim University. In 1933 he joined the faculty of the Fergusson College at Pune. Here he became known as an exacting professor, not easy to understand and not popular with those who expected to be spoon-fed, but highly admired by the bright and serious students who were willing to work hard. After 14 years he left because of serious differences with the authorities. He was not happy with the 'examination-ridden system and uninspiring standards of education'.

In 1946 he was invited by Homi Bhabha to join the newly established Tata Institute of Fundamental Research (TIFR) in Mumbai. His warm relationship with Bhabha soured within a few years, mainly due to a clash of personalities. Bhabha strayed away from research and focused on institution-building, and became a managerial scientist. There were ideological differences too – while Bhabha lobbied for *atomic* energy, Kosambi was all for *solar*.

His contract at TIFR was not renewed in 1962. In 1964 he was appointed scientist emeritus by the CSIR and affiliated himself to the Maharashtra Association for the Cultivation of Science at Pune.



Major-General Enayat Habibullah was the first commandant of the National Defence Academy at Khadakwasla near Pune. Being an amateur archaeologist himself he invited Kosambi to set up the Archaeological Society in the "hobbies" section of the academy. Here Kosambi guided an enthusiastic band of instructors and cadets to hunt for microliths and megaliths, rock carvings and other artefacts.



rock carvings and other artefacts.



**Kosambi's mapping function**  
Allows for interference (I), whereby one crossover prevents other crossovers in the same region:

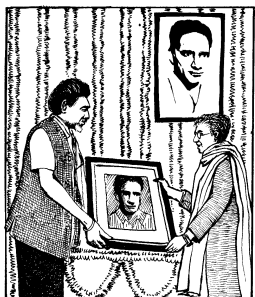
$I = 1 - \frac{\text{observed\_number\_double}}{\text{expected\_number\_double}}$   
The amount of interference allowed in the Kosambi map decreases as the loci get further apart, and is zero for loci:

$$x = \frac{1}{4} \ln \left( \frac{1+2\theta}{1-2\theta} \right)$$

The reason for underdevelopment is precisely that our raw materials and our great markets were exploited by the foreigner to his own advantage. Our products were taken away for the price of the cheap labour needed to take them out of the earth, and we paid the highest prices for the finished goods. In a word, the developed countries with very few exceptions are developed precisely because they made profit both ways from us; we were never paid for the value of the things taken away. It is this that helped in the development of

**Freedom is the recognition of necessity; science is the cognition of necessity.** The first is the classical Marxist definition of freedom, to which I have added my own definition.

Control over history is not to be attained by the passive suffering that has perpetuated Indian life from generation to generation. The time has now to make history seriously the out, conscious design in



Prof Meera Kosambi being presented a portrait of her father D.D. Kosambi during the Centenary Celebrations 2007

In 1931 he married Nalini Madgavkar. Their elder daughter Maya died early of cancer. The younger daughter Meera Kosambi is a well known social scientist based in Pune.

In 1949, he was a visiting professor in 'path-geometry' at Chicago and later a guest of the Institute for Advanced Study at Princeton where he had extensive discussions with Albert Einstein.

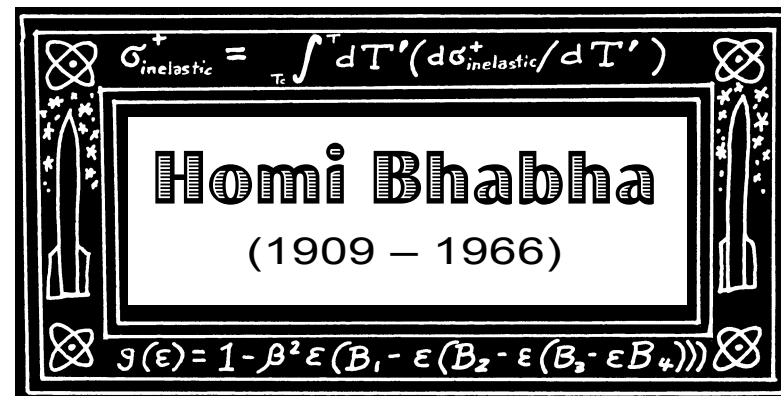
Kosambi believed in the dialectical method but was strongly critical of the orthodox left parties and called them *Official Marxists (OM)*. His criticism of *atomic energy* did not endear him to Bhabha. When Nehru wrote the *Discovery of India*, Kosambi wrote a scathing review exposing Nehru's shallow understanding of Indian History. For his fierce independence Kosambi was sidelined both by the government and the left parties. He won the first Ramanujan Memorial prize in 1934 (at the age of 26), and a special Bhabha prize in 1947. It is a reflection of the insensitivity of the Indian state that this amazing intellectual never got a state award worthy of his stature.

Kosambi's birth centenary year 2007 was celebrated in Pune with a series of lectures by leading intellectuals. The Government of India belatedly issued a postage stamp in his memory and gave a grant of Rupees One Crore to set up a Kosambi Chair in the University of Pune.

Though this remarkable genius passed away young at the early age of 58, on 29th June, 1966 he will be remembered for centuries for his brilliant contributions to diverse fields of human knowledge.

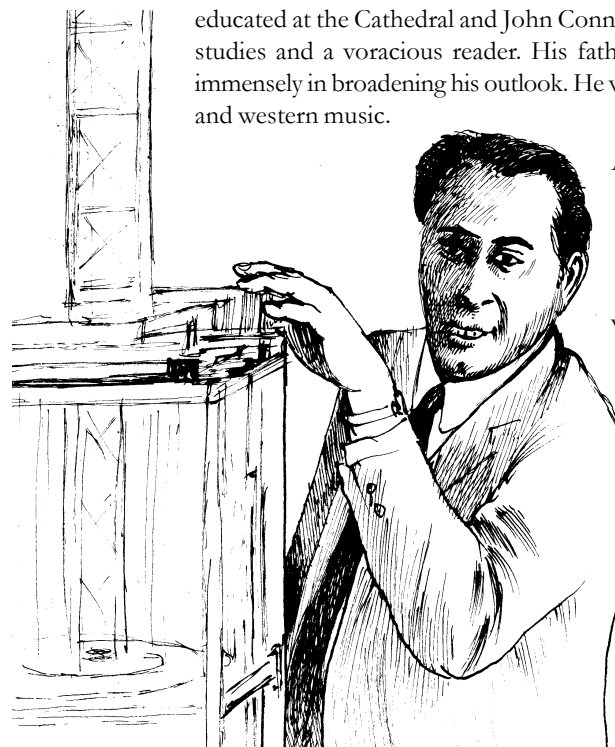


Kosambi was an active member of the World Peace Movement. As an emissary of Peace he was very fond of the Panchsheel symbol - a bird of peace with a twig in its beak. He insisted in having this symbol printed in his book *Exasperating Essays*.



"No country which wishes to play a leading role in the world can afford to neglect pure or long-term research," said Bhabha. He was the sole architect of India's Nuclear Energy programme and nurtured its Space and Electronics programmes. He created institutions of excellence around accomplished individuals. Institutions like the TIFR, BARC and ISRO bear testimony to his futuristic vision.

Homi Jehangir Bhabha was born on 30 October 1909 in Bombay in a distinguished family related to the Tata's. The house he was born in was later destined to be the cradle of India's Nuclear Programme. Young Homi was educated at the Cathedral and John Connon High School. He was brilliant in studies and a voracious reader. His father's wonderful library helped him immensely in broadening his outlook. He was also keenly interested in painting and western music.



After passing Senior Cambridge he studied for a few years at the Royal Institute of Science in Bombay. Then he proceeded to Cambridge for higher studies. His father wanted him to become an engineer so that he could later join the Tata Group as an executive. But Homi was only interested in studying physics. Physics was then undergoing a major revolution and Cambridge was the place for action.





Physicists Albert Einstein, Hideki Yukawa, John Wheeler, and Homi Bhabha

Homi's liberal father allowed him to study for the Mathematical Tripos after completing the Mechanical Sciences Tripos. In 1932, the young Bhabha won the Rouse Ball Travelling Fellowship. This enabled him to work with Wolfgang Pauli in Zurich and Enrico Fermi in Rome. Later, the Isaac Newton Studentship allowed him to spend time at the Niels Bohr's Institute in Copenhagen. In between Bhabha completed his PhD thesis under the supervision of R. H. Fowler. Fowler was also the guide of the brilliant astrophysicist S. Chandrasekhar.

Bhabha's Cambridge days were exciting. He discovered the electron-positron scattering process which is now known as *Bhabha scattering*. Along with Walter Heitler he enunciated the *cascade theory* describing cosmic-ray showers. These contributions established him as young and talented physicist.

In 1939 Bhabha returned to India for a brief holiday. Just then the Second World War broke out. The onset of war dried up availability of funds for research in Europe. In a sense it was a blessing in disguise for now Bhabha had to look for a job in India. His reputation got him a research position at the Indian Institute of Science, Bangalore. Here, with a grant from the Sir Dorab Tata Trust he started research on cosmic rays.

During his stay in Bangalore Bhabha's theoretical work led to the construction of an equation for a particle with two mass-states (now called the *Bhabha Equation*). He also collaborated with Harish Chandra who later attained fame as an eminent mathematician. To study cosmic ray behaviour at the higher altitudes he built Geiger Counter Telescopes and flew them in Air Force planes.

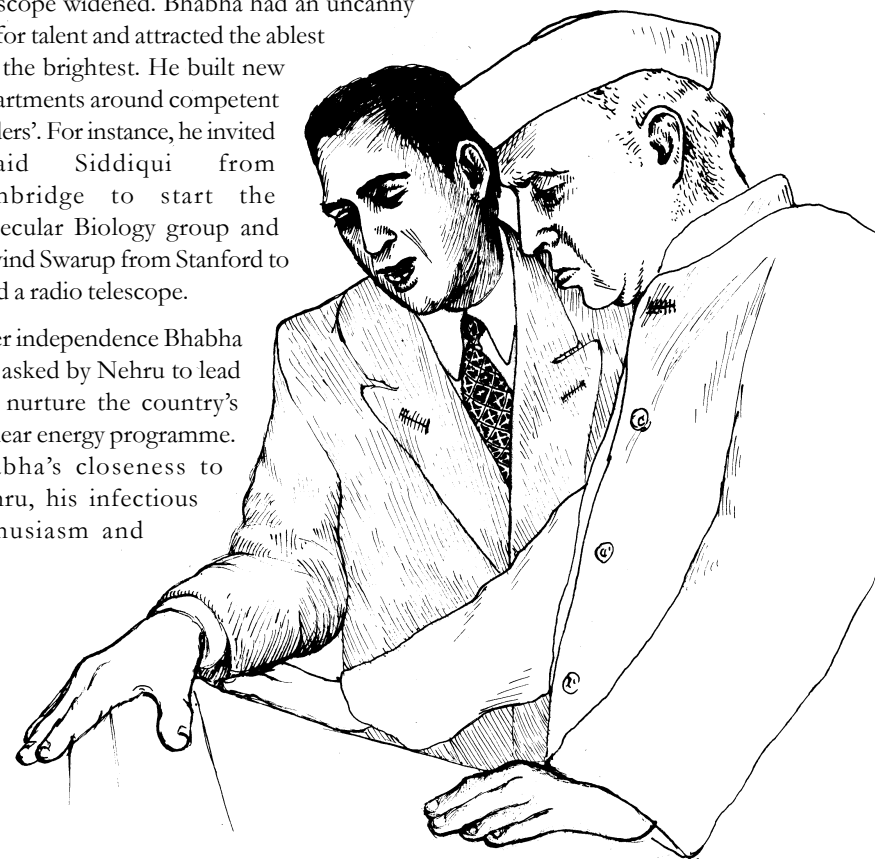
With the end of the war Bhabha was again confronted with a choice. Should he return to Europe which offered abundant opportunities or should he stay back in India? He sought the advice of his friend J. R. D. Tata asking, "*It is one's duty to stay in one's own country and build schools comparable with those that other countries are fortunate in possessing?*"

Bhabha was of the firm opinion that these *schools of excellence* would provide the scientists for the country's Nuclear Energy development and India will not have to seek these experts from abroad. With a seed grant of just one lakh rupees Bhabha founded the Tata Institute of Fundamental Research (TIFR) on June 1, 1945. The Institute started in Bangalore but within a few months was shifted to Bombay and located in the very house where Bhabha was born!

India's first Prime Minister Jawaharlal Nehru shared Bhabha's world view on the need to build up indigenous capabilities in science and technology. He provided Bhabha the political space, resources and a free hand to build the country's scientific infrastructure.

Initially the TIFR concentrated on cosmic rays and mathematics. But slowly the scope widened. Bhabha had an uncanny eye for talent and attracted the ablest and the brightest. He built new departments around competent 'leaders'. For instance, he invited Obaid Siddiqui from Cambridge to start the Molecular Biology group and Govind Swarup from Stanford to build a radio telescope.

After independence Bhabha was asked by Nehru to lead and nurture the country's nuclear energy programme. Bhabha's closeness to Nehru, his infectious enthusiasm and







boundless energy cut through the proverbial bureaucratic red-tape and things began to take shape. Both the TIFR and the Indian Atomic Energy Programme blossomed in a few short years.

His achievements drew a shower of awards on Bhabha. He was elected a Fellow of the Royal Society in 1941 awarded the Hopkins prize in 1948, the Padma Bhushan in 1954 and countless honorary doctorates. He will always be remembered as the Father of Nuclear Energy in India.

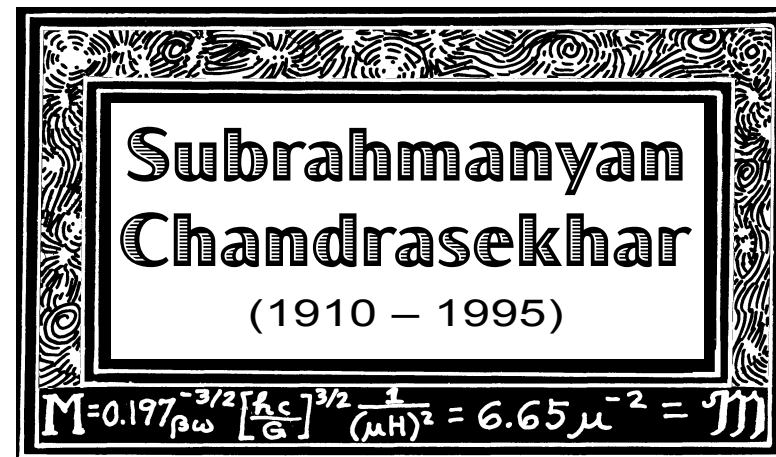
Though a theoretical physicist, Bhabha was also well versed in technology. He laid the foundation for India's Space programme which was later nurtured and steered with great care by Vikram Sarabhai and Satish Dhawan. After the 1962 Chinese attack Bhabha realised India's backwardness in electronics. He prepared a blueprint to help the country leapfrog in this vital area.

Bhabha was a multifaceted personality, as fluent with complex mathematics as he was with the nuances of classical music. He was an artist and a connoisseur of all the good things in life – art, music, literature, architecture, landscaping etc. For his catholicity of interests he was hailed as a modern day Leonardo. After the TIFR building was constructed Bhabha commissioned the painter Maqbool Fida Hussain to do a wall mural, for which he was then paid a princely sum of Rs 15,000/-. Few people know that 1% of the TIFR budget was earmarked for buying 'art'. Bhabha's paintings still adorn the TIFR and BARC campuses. He represented the best in both the sciences and the arts. Because of his many preoccupations he never married. When a reporter once asked him about his marriage, he said, *"I am married to creativity."*

As a young man Bhabha told his father, *"Who says we can't do science in India?"* Not only did he do cutting-edge research but he set up *institutes of excellence* to enable thousands of Indians to do the same.

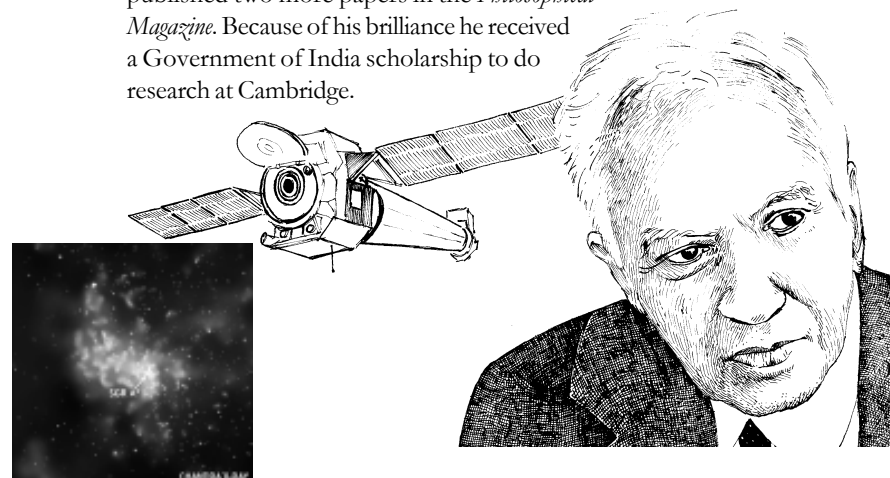


At the height of his career Bhabha's life was snatched away when the plane he was travelling in crashed on Mont Blanc in France on 24 January 1966. All the passengers died leaving the nation in shocked grief.



The twentieth century witnessed many scientists who revolutionised our understanding of nature. Dr. S. Chandrasekhar, an Indian-born scientist was one such luminary. His contributions to our understanding of physics, astrophysics and applied mathematics were legendary.

Chandrasekhar was born on 19 October 1910 in Lahore (now in Pakistan). He was the son of Sri C. Subrahmanya Iyer, brother of India's first science Nobel Laureate Sir C.V. Raman. Sri Iyer, who worked as an Accountant General for the Indian Railways, had a keen interest in music. Chandra was home schooled until the age of 11. He then joined the Hindu High School in Madras and went on to study BA in Physics at the Presidency College, Madras. He was an outstanding student and destined for great things. At the age of 18 he published his first scientific paper *Compton scattering and the new statistics* in the *Proceedings of the Royal Society*. Before completing his undergraduate studies he had published two more papers in the *Philosophical Magazine*. Because of his brilliance he received a Government of India scholarship to do research at Cambridge.





Cartoon by Gopi Gajwani,  
Courtesy IUCAA library

During the ship journey to England, Chandra gave serious thought to an astronomical problem. How does a star (such as our sun - a medium-sized star) finally end? After several years of extensive work he concluded that stars smaller than 1.44 times the solar mass ended up as *White Dwarfs*. This limit of 1.44 times the solar mass has got entrenched in astrophysics as the famous *Chandrasekhar Limit*.

During 1930-36, Chandra worked on this problem at the Cambridge University under Prof. Ralph H. Fowler. In 1933 he obtained his PhD and was elected a Fellow of Trinity College. In

1935 he was invited to present his results by the Royal Astronomical Society. Here he ran into unexpected trouble. Sir Arthur Eddington, the world famous astronomer not only severely criticised Chandra's conclusions but even ridiculed it. Chandra, taken aback by the fierce attack, defended his theory strongly. However, after several years, practical observations settled the issue in Chandra's favour. Eddington's egg-headedness slowed the progress of astronomy by at least two decades!

In July 1936 Chandra married his neighbour Lalitha. It was not an arranged marriage. Lalitha was a graduate and worked as a school head-mistress.

In 1937 Chandra joined the University of Chicago and was posted to its Yerkes Laboratory. He soon rose to become a Professor in 1944. In the early 1950's he became more closely associated with the main University at Chicago. In 1953 he and his wife became American citizens.

Chandra's devotion to his students was legendary, akin to the *guru-shishya* tradition of India. In 1946, he used to drive, once a week, a distance of 250 kilometres from his observatory to Chicago to teach a class of just two students! But he knew exactly what he was doing. These two American-Chinese students Lee and Yang later won the Nobel Prize for Physics in 1957.

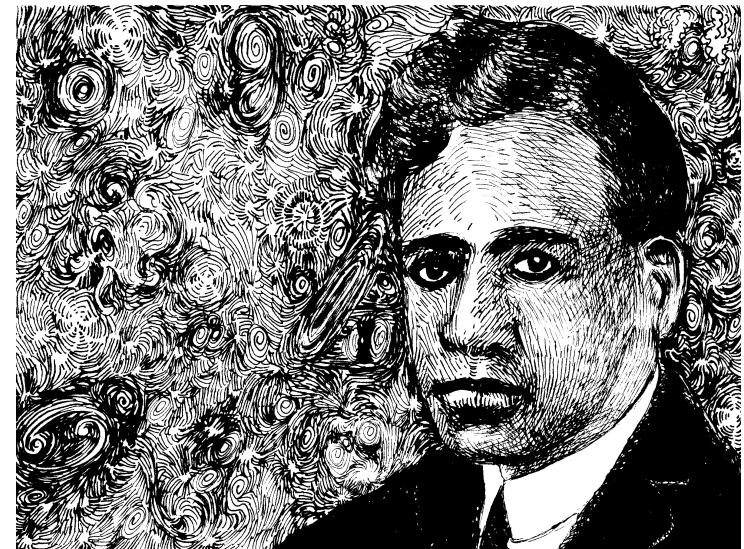
Chandrasekhar's working methodology was unique. He felt that the mind dulled if one continued to work in the same narrow field year after year. So, every decade or so he would venture into something totally new, focus all his energies, master it, make original contributions and sum up his research into one definitive book. Marvin Goldberger said, "*He would produce an infinite series of papers followed by an infinitely thick book on the subject.*" And then he would

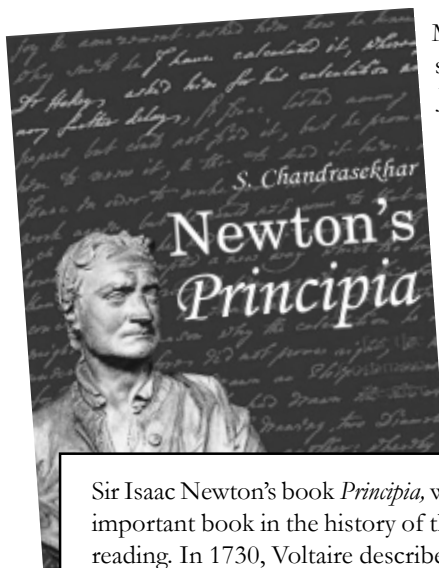
move to another field. Until his very end he frequently switched subjects but made original contributions to every single field he chose to study. He believed in systematic hard work.

Many great scientists become victims of their own success by succumbing to positions of power. Chandra on the other hand rejuvenated himself constantly in the company of young scientists. He was happiest when problems took on their own momentum and one problem generated another. In the end he felt obligated, almost compelled to solve them.

First he worked on *Stellar Dynamics* – which deals with the evolution of galaxies. In the 1940's he moved to *Radiative Transfer* – dealing with the passage of radiation through a star's atmosphere. In the 1950's he worked on *Hydrodynamic Stability* – the study of turbulence - which is an extremely complicated natural phenomenon. In the 1960's sophisticated telescopes led to exciting discoveries of pulsars and quasars. This observed phenomenon needed a theoretical explanation. He used the General Theory of Relativity to study Black Holes and summarised it in his classic book, *The Mathematical Theory of Black Holes*, published in 1983. He continued to work on this subject till his death on 21 August 1995.

Though Chandra lived most of his life abroad, India was always on his mind. Ramanujan – the great Indian mathematician - was Chandra's role model for a life dedicated to science. He helped in founding the Ramanujan Institute of





Mathematics in Madras. He also helped secure a pension for Ramanujan's wife Janaki who was languishing in poverty.

Such total dedication naturally brought its rewards in results and recognition. He was elected a Fellow of the Royal Society of London in 1944, awarded the National Science Medal of the United States in 1966, the Padma Vibhushan from the Government of India in 1968 and to crown it all the Nobel Prize for Physics in 1983.

Sir Isaac Newton's book *Principia*, written in 1687, is regarded as the most important book in the history of the physical sciences. But it is not easy reading. In 1730, Voltaire described the book as incomprehensible and obscure. Chandra derived the important results of the *Principia* by modern techniques. He conceded, however that Newton's methods were aesthetically better.

Chandra's books and monographs have all become classics. In addition to their thoroughness, lucidity and accuracy they have a highly personal and distinctive style.

Chandra had an abiding interest in music and literature and had lapped up the works of all the great Russian masters – Dostoevsky, Turgenev, Tolstoy and Chekov. Hardy, Ibsen, Shaw and Shakespeare were his favourite writers. He lectured frequently on the relationship between the arts and the sciences, and expounded on this at length in his book *Truth and Beauty: Aesthetics and Motivations in Science*.

While other illustrious scientists' work might have had greater impact, Chandra stands alone in a broader perspective of a life devoted to science. As a mark of respect, the most sophisticated X-ray observatory to date launched by NASA in 1999, was fittingly named *Chandra* to immortalise this luminary.

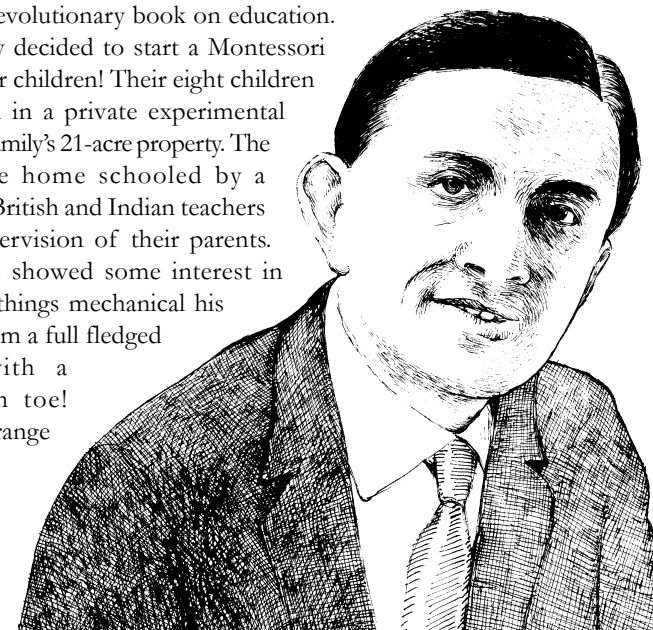


## Vikram Sarabhai (1912 - 1971)

As a young boy Vikram Sarabhai loved a few cycling stunts. After his bicycle gained sufficient momentum, he would cross his arms over his chest and place his feet on the handlebars. If the road ahead was straight he would shut his eyes and let the bicycle carry him as far as it would go. All this while the terrified servants chased him and begged him to stop. This daredevilry is a bit difficult, to associate with his later scholarship – author of 80 scholarly papers on cosmic rays!

The seeds of this remarkable life were probably sown in early childhood and fostered by his unusual upbringing. Vikram Sarabhai came from a prosperous business family - which owned the famous Calico textile mill in Ahmedabad. While returning by ship in the 1920's his father Ambalal and mother Sarla read Montessori's revolutionary book on education.

They promptly decided to start a Montessori school for their children! Their eight children were educated in a private experimental school on the family's 21-acre property. The children were home schooled by a succession of British and Indian teachers under the supervision of their parents. When Vikram showed some interest in tinkering and things mechanical his father gifted him a full fledged workshop with a supervisor in toe! Apart from a range



of extra-curricular activities the children had the company of distinguished visitors like Tagore, Jawaharlal Nehru and Rukmini Devi Arundale.

The Sarabhais, in addition to being wealthy, were close to Mahatma Gandhi and were known for their strong sense of social responsibility. Vikram's aunt, Anusuiya founded the city's first trade union of textile workers. His sister Mridula was deeply influenced by Gandhi. She was actively involved in the freedom movement and went to jail on several occasions.

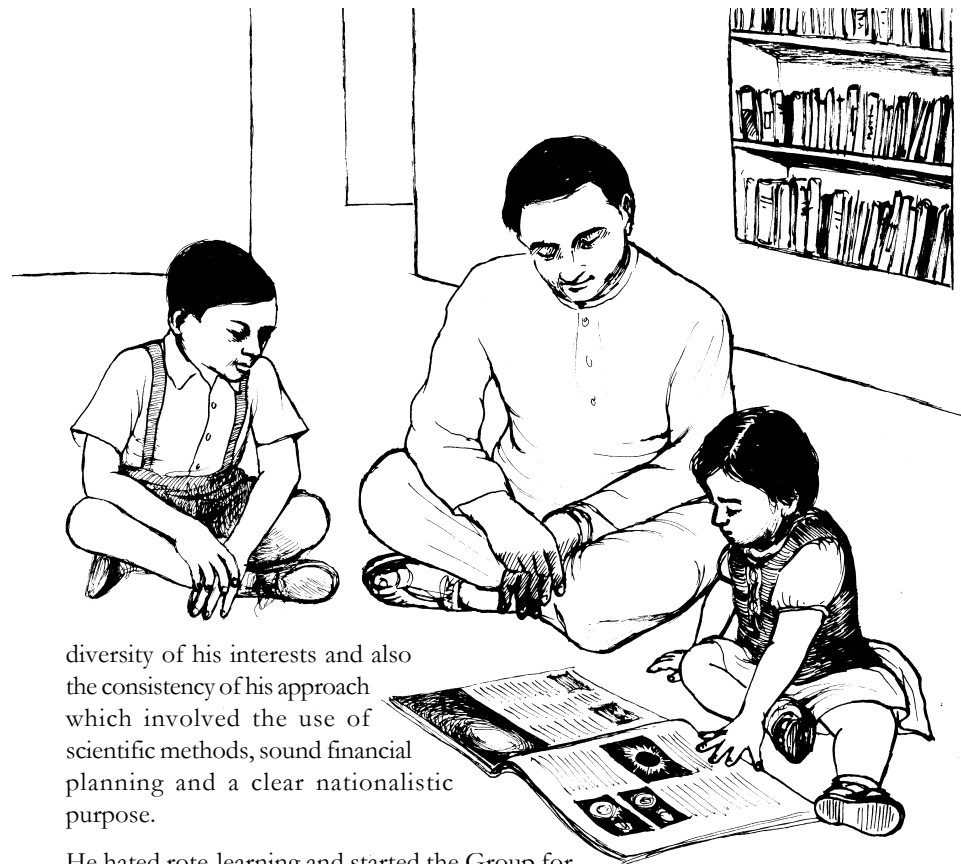
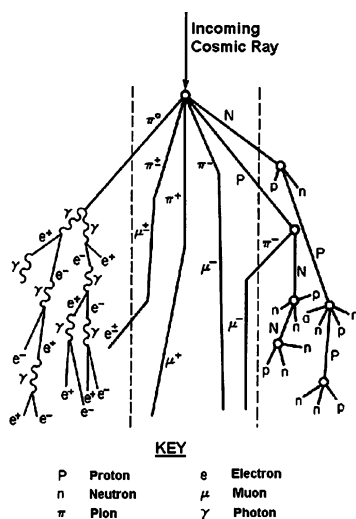
After schooling Vikram joined the Gujarat College, Ahmedabad, but before he graduated he left India to join St. John's College at Cambridge University. In 1939 he obtained his Tripos in Natural Sciences. The outbreak of World War II forced him to return to India. Here he went to work under Dr C.V. Raman on cosmic rays at the Indian Institute of Science, Bangalore.

The study of cosmic rays turned Sarabhai's attention inevitably towards space science and technology. This interest lay dormant until opportunity beckoned him to play a major role in India's space programme. While at Bangalore, Sarabhai met and married Mrinalini Swaminathan, an accomplished *Bharathanatyam* dancer. They had two children a son Karthikeya and a daughter Mallika.

In 1945, with the war over, Sarabhai returned to Cambridge. He obtained his PhD degree in 1947 on the topic, *Cosmic Ray Investigations in Tropical Latitudes* under the guidance of E.S. Shire. The thesis also included some work on nuclear fission.



In the fervently idealistic post-Independence era, Vikram Sarabhai established several institutions such as the Physical Research Laboratory; the Darpana Dance Academy, which he co-founded with his wife, Mrinalini; the Ahmedabad Textile Industry's Research Association (ATIRA), India's first textile research cooperative; the country's first market research agency, the Operations Research Group; the Indian Institute of Management, (IIM/ Ahmedabad) and helped in setting up the National Institute of Design (NID). The range of activities reveals the astonishing



diversity of his interests and also the consistency of his approach which involved the use of scientific methods, sound financial planning and a clear nationalistic purpose.

He hated rote-learning and started the Group for Improvement of Science Education (GISE). This later became a part of the Nehru Foundation for Development. He set up the Community Science Centre in Ahmedabad which was inaugurated by C. V. Raman in 1968 with his famous lecture *Why is the sky blue?* It is amazing how he found the time and energy to make outstanding contributions in so many fields.

A man of such energy and drive could hardly remain unnoticed. In 1962 Vikram Sarabhai was invited by Prime Minister Nehru to organise India's space research. While the superpowers were deploying space technology for *control* and *military power* Sarabhai had a different vision. He dreamt of a unique space programme for India - where satellites would be used for mass education, development communication, weather forecasting and mineral prospecting.

He used technology to serve the needs of the masses while simultaneously nurturing a sophisticated scientific work culture. He believed in India's capability to 'leapfrog'. He had great faith in the ability of technology to enable developing countries to circumvent the long, arduous process followed by the west.

Sarabhai laid the foundation for SITE (Satellite Instructional Television Experiment) a mass learning programme for millions of unschooled Indian children. He established a rocket launching station at Thumba, Kerala very close to the magnetic equator. It was later expanded to a full-fledged Space Science and Technology Centre (today this centre aptly bears the name Vikram Sarabhai Space Research Centre). Another rocket range was established in Sriharikota in Andhra Pradesh and a Satellite Communication Centre in Ahmedabad.

After Bhabha's untimely plane crash, Sarabhai became the Chairman of the Atomic Energy Commission (AEC). Influenced by Gandhi, Sarabhai had a highly nuanced approach to the sensitive issue of nuclear weapons. Obviously, the hawks in the nuclear establishment did not like him and he had his share of critics. He attended Pugwash Conferences to discuss misuses of atomic power and seek peaceful uses of nuclear energy.

If India has demonstrated indigenous capability in making low-cost satellites, of successfully launching its own moon probe - *Chandrayan* the credit certainly goes to the foundation laid by Vikram Sarabhai. He chose a passionate team and nurtured it assiduously— A. P. J. Kalam, E. V. Chitnis, Vasant Gowarikar, Pramod Kale, U. R. Rao, Kasturirangan and other pioneers.

Vikram Sarabhai won the gratitude of his nation even during his rather short life. He was awarded the Shanti Swarup Bhatnagar Memorial Award for Physics in 1962, Padma Bhushan in 1966 and posthumously the Padma Vibhushan in 1972.

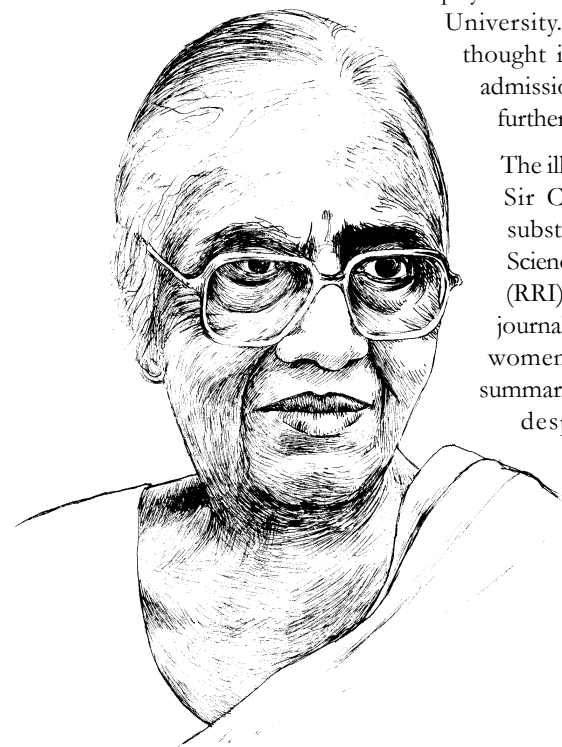
Vikram Sarabhai went about his work like a man possessed. Once he gave an appointment to A. P. J. Kalam at 3.30 a.m.! He burnt the candle at both ends, determined to achieve his goals in the shortest possible time. His strenuous lifestyle took a toll and Sarabhai suddenly died of a heart attack on 30 December 1971. The scion of a rich family, who could have easily lived a life of luxury, chose to burn himself up prematurely in the service of his country. India owes an eternal debt to Sarabhai for putting her in the league of the world's great space powers.

In 1974, a moon crater was named after Vikram Sarabhai. The International Astronomical Union at Sydney, Australia, decided that crater *Bessel* in the *Sea of Serenity* would be known as the **Sarabhai Crater**.



Kamala Sohonie was the first Indian woman to get a PhD in a scientific discipline. She carried out detailed biochemical studies on three major groups of food items consumed by the rural poor and established their nutritive values.

Kamala was born in 1912. Kamala's father Narayanrao Bhagwat and her uncle Madhavrao were distinguished chemists. They were amongst the first to graduate from the Indian Institute of Science, Bangalore. Kamala did her BSc, with physics and chemistry from the Bombay University. As the university topper she thought it would be easy for her to get admission in the Bangalore institute for further research. But it wasn't a cakewalk.



The illustrious scientist Nobel Laureate Sir C. V. Raman who contributed substantially to the Indian Institute of Science (IISc), Raman Research Institute (RRI) and laid a strong foundation for journals in India was dead against having women students. So in 1933, Raman summarily dismissed Kamala's application despite her having topped the university merit list! Kamala was not the one to be cowed down. She confronted Raman who later relented.

After her *satyagraha* in Raman's office Kamala was admitted on probation – with a rider – that her presence should not prove a disturbance to the male researchers! Kamala was deeply hurt. But she had no choice but to accept.

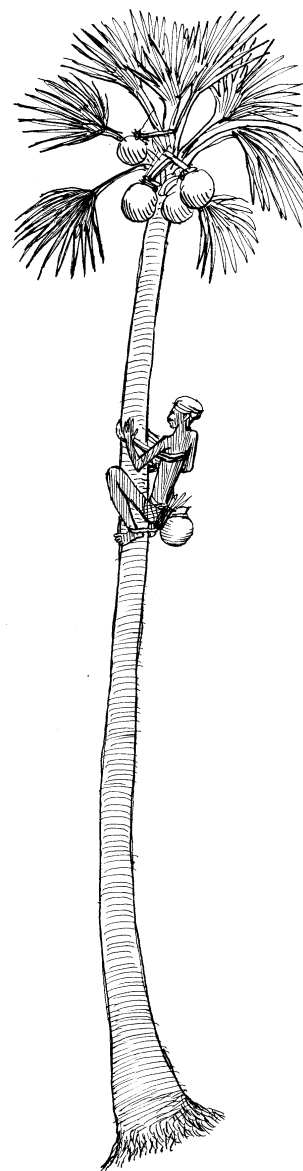
Kamala was to later recount. *“Though Raman was a great scientist, he was very narrow-minded. I can never forget the way he treated me just because I was a woman. Even then, Raman didn't admit me as a regular student. This was a great insult to me. The bias against women was so bad at that time. What can one expect if even a Nobel Laureate behaves in such a way?”*

After a year Raman was satisfied with Kamala's sincerity and allowed her to do regular research in biochemistry. From then on he started admitting lady students to the institute. This was a landmark victory for Kamala. Her struggles made life considerably easier for other aspiring women scientists.

At the IISc, Kamala worked very hard under her teacher, Shri Sreenivasayya – who had an abiding influence on her. He encouraged her to read the works of great masters in biochemistry and even to correspond with them. Here she worked on proteins in milk, pulses and legumes, which had important implications for malnourished India. In 1936, as a graduate student, she was the first person to work on pulse proteins. She submitted her research to the Bombay University and received her MSc degree. She then went to Cambridge University and first worked in the laboratory of Dr Derik Richter who offered her a spare table to work during the day, on which he himself slept at night.

When Dr Richter left to work elsewhere, Kamala continued her work under Dr Robin Hill, on plant tissue. While working on potatoes she found that every cell of a plant tissue contained the enzyme ‘cytochrome C’ which was involved in the oxidation of all plant cells. This was an original discovery which embraced the entire plant kingdom.

Her dreams to work with great masters soon materialized when she got two scholarships. The first one was in the Sir William Dwan Institute of Biochemistry at the Cambridge University with the



*Neera, also called Sweet Toddy or Palm Nectar is a sap extracted from inflorescence of various species of Toddy palms. It is sweet, oyster white, and translucent like water. It is widely consumed in India. It is highly nutritious.*

Nobel Laureate Prof. Fredrick Hopkins. Here she worked in the areas of biological oxidation and reduction. The second scholarship was an American travelling fellowship which enabled Kamala to meet eminent scientists in Europe.

Kamala submitted a short thesis describing her finding of ‘cytochrome C’ in respiration of plant tissue, to Cambridge University for her PhD degree. Her entire PhD – research and writing took only 14 months and consisted of just 40 typed pages! She was the first Indian woman to get a PhD in a science discipline!

In 1939 she returned to India, and worked as the head of the newly opened Department of Biochemistry at the Lady Hardinge College, New Delhi. Later she became the Assistant Director of the Nutrition Research Laboratory, Coonoor. Here she researched on the effect of vitamins. In 1947, she married Sri M. V. Sohonie, an actuary by profession and moved over to Bombay.

In Bombay she joined the newly opened Biochemistry Department at the (Royal) Institute of Science. She inspired her students to do relevant research. Many of her research students later became distinguished scientists. Kamala along with her students carried out detailed biochemical studies on three major groups of food items consumed by the rural poor and thus established their nutritive values. These studies involved leguminous proteins, trypsin inhibitors and other compounds which reduce the digestibility of Indian legumes, *Neera*, *palm gur* and *palm molasses*, and *dhanata* paddy flour—formed during milling and polishing rice. The subjects of her research were of great relevance to Indian societal needs as these food items are consumed by the poorest people. She started her pioneering work on *Neera* at the suggestion of the first Indian President Dr. Rajendra Prasad.

She advised the Aarey Milk project on improving the quality of their products. *Neera* is a sap extracted from the inflorescence of various species of Toddy Palms. It is sweet and highly nutritious. The introduction of *Neera* in the diet of tribal malnourished adolescent children and pregnant women caused significant improvement in their overall health. Kamala Sohoni received the President's Award for her pioneering work on the nutritional value of *Neera*.

CONSUMER GUIDANCE SOCIETY OF INDIA



She was an active member of the Consumer Guidance Society of India (CGSI) where she worked with double vigour. In 1982-83 she was elected President of the CGSI and wrote many articles on consumer safety for their magazine *Keemat*.

Though she was very happy with her research work, Kamala was quite distressed with the jealousies and politics at the Institute where the Directorship was denied to her for many years. She attributed her successful scientific career to her father, teacher—Sreenivasayya and her loving husband.

When she finally became the Director, Dr Derik Richter - her first guide at Cambridge, remarked that she, *"made history by being the first lady Director of such a big science institute."*

Kamala Sohoni's life symbolized the struggle waged by the pioneering Indian women scientists. Brilliance and family support alone did not ensure a woman's entry into male dominated science. When Dr Satyawati – the first woman Director General of the Indian Council of Medical Research (ICMR) learned of Kamala Sohoni's struggles and her work she decided to make amends. She invited Kamala, who was then 84 and felicitated her in an impressive ceremony in New Delhi. Kamala Sohoni passed away in 1998, at the age of eighty six.

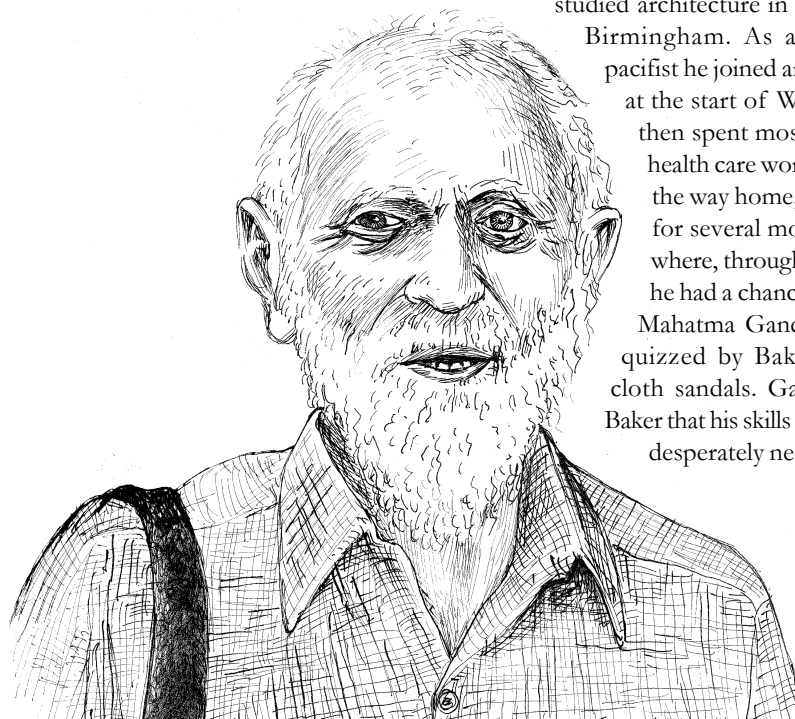


*"I never build for classes of people – high income, middle income or low income groups, tribals or fishermen. I only build for a Matthew, a Bhaskaran, a Muneer or a Sankaran."*

-Laurie Baker

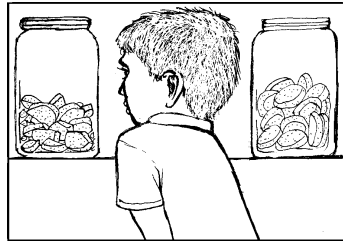
Laurie Baker was a rare architect who touched the lives of the poor. He built low-cost, low-energy, climatically suited and aesthetic houses for people's real needs.

Laurence Wilfred Baker was born in 1917 in Birmingham. He grew up and studied architecture in the mill town of Birmingham. As a Quaker and a pacifist he joined an ambulance unit at the start of World War II, and then spent most of the war as a health care worker in China. On the way home, he was stranded for several months in Bombay where, through Quaker friends, he had a chance encounter with Mahatma Gandhi. Gandhi was quizzed by Baker's hand-made cloth sandals. Gandhi convinced Baker that his skills and expertise was desperately needed in India.





Baker learnt frugality and good value for money early in life. As a child he would spend his pocket money buying biscuits from the local bakery. He soon discovered that for the same money he could buy double the amount of broken biscuits. And the broken biscuits tasted just as good! This lesson he never forgot.



Deeply inspired by Gandhi, Baker returned to India a few months later and began building treatment centres for leprosy patients. In 1948, he married Dr. Elizabeth Jacob – a medical doctor from the Christian Medical College, Vellore. The couple then moved to a remote village in the hills of Pithoragarh in Uttar Pradesh and ran a hospital where Elizabeth was the only doctor and Baker was the rest of the hospital staff! When the American educationist Welthy Fisher wanted to set up the *Literacy House* in Lucknow she was told that there was only one architect in India who could translate her dream vision into a blueprint. Baker also designed *Noor Manzil* the first psychiatric hospital in Lucknow.

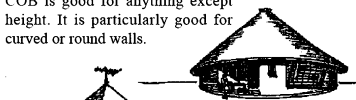
In the late sixties Baker returned to his wife's home state of Kerala and settled in Trivandrum. He started practicing as a full time architect only at the age of fifty! Baker organised his work as a designer-builder in the manner of a traditional Indian master craftsman. He never hired an office or an assistant,

and often sketched his plans on waste paper, designing largely on site.

Unlike architects who only drew 'lines on paper'

Baker was an expert builder – an adept mason, a skilled carpenter. His projects were executed not by engineers but by teams of craftsmen he had himself trained. His hands-on approach with no middlemen enabled him to cut costs to the bone. He was deeply

COB is good for anything except height. It is particularly good for curved or round walls.



PISE or RAMMED EARTH is strong and ideal for solid, squat single storey houses.



ADOBE or SUN DRIED BRICKS can easily cope with two storey houses.



PRESSED BRICKS are smooth and very strong and can build three storeys.



WATTLE & DAUB is elegant and fine for seismic zones and can be done wherever there is cane or bamboo.



But parties blamed each other.....

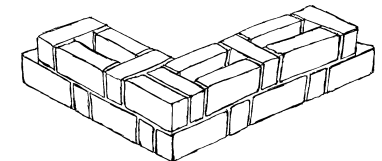
sensitive to the environment and seldom used energy guzzling steel or cement. He never failed to point out, "*Cement is younger than me.*" This was true as energy intensive cement was introduced on a large scale only after the First World War.

It was in the Himalayas that Baker saw how traditional Indian architecture reflected thousands of years of trial-and-error research in energy efficiency. People used local stone and timber found within a few hundred yards of their houses. Seeing this reminded Baker of one of

Gandhi's beliefs – that all buildings should be made of materials found within 5-miles of the construction site.

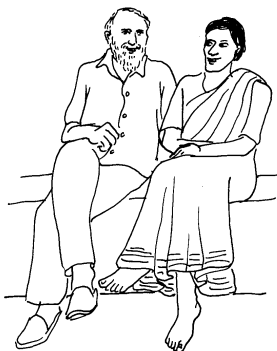
Baker was not always able to follow that principle, but came close to it. He was profoundly hostile to glass and steel – both energy guzzlers. But he loved embedding coloured bottles in walls for kaleidoscopic light-effects. Bricks he loved and often laid them in *rat-trap* bonds to save 25% bricks and gain great insulation for the wall. His brick *jaalis* (wall cavities) brought in cool air from outside while roof vents pushed out the hot air. For mortar he used lime which in Kerala could be made on the spot using clamshells. He replaced steel and reinforced his slabs with split bamboos at one-fifth of the cost. His favourite material however, remained *MUD* – which used no fuel, could be found close by, and was free. Fifty-eight percent of all buildings in India were made of mud and had withstood the ravages of weather for hundreds of years. Mud was also completely reusable. You could tear down your old house, add water, and make a new one. That couldn't be done with glass and steel.

Baker used traditional materials, skills and designs - tried and tested for thousands of years to construct comfortable homes and offices that had running water, electricity and sometimes garages. He was convinced that '*architecture was too important to be left to architects*'. He wrote a dozen do-it-yourself booklets with titles like *How to reduce building costs*, *Rubbish* and *Mud* illustrated with his own pen-and-ink diagrams. Many of these have



Rat-trap masonry saves money by using 25% less bricks - and also makes a building better insulated because of the air spaces.





Laurie and Elizabeth Baker

been translated into regional languages. Two of the more recent booklets *Rural Community Buildings* and *Cost Reduction for Primary School Buildings*, were published on Baker's 80th birthday. Two of his most celebrated buildings are the Centre for Development Studies (CDS) and a modest *Coffee House* near Trivandrum's bus station.

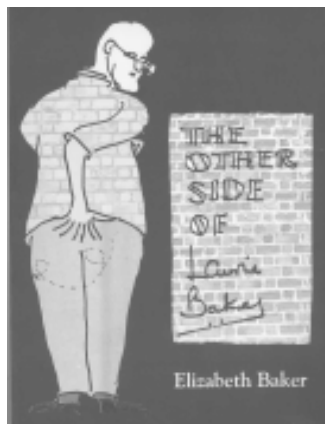
Recycling came naturally to Baker. His bathrooms, for example, used bits and pieces of waste glass as tiles. He embedded several hundred broken roof tiles every foot or two

in his building's concrete roof, a signature Baker technique. The checkerboard broken tiles reduced the amount of concrete by 30%. He never wanted his buildings to rise above Kerala's coconut palm cover!

Baker was not just an architect. He embraced life to the fullest and on various occasions became an anaesthetist, missionary, gardener, cook, farmer, veterinarian, ambulance driver, carpenter, mason, poet, cartoonist etc.

Baker was conferred several honorary doctorates. The British government bestowed the Order of the British Empire and MBE. In 1990 he received the inaugural UNO Habitat Award and UN Roll of Honour. On various occasions he was inducted into many high profile government committees. In 1990 he was awarded the Padma Shri. But he was happiest to be made an Indian citizen in 1988. Elizabeth and Baker adopted three children – son Tilak and daughters Vidya and Heidi.

While constructing his own house *Hamlet* he practised the same concepts he preached and popularized. Indeed, *his life was his message*. He died peacefully at the ripe age of 90, on April fool's day 2007. Even in death he pulled a fast one on his detractors. As the builder of *Hamlet* he had no confusion about his role or identity *to be or not to be*. In the end one can only echo Shakespeare's Mark Antony: "*Here was a Baker! When comes such another?*"



Elizabeth Baker



*"The brave women I knew have grown old.  
Each was like a tree, or like a lighthouse,  
Or like a gull circling the lighthouse,  
Or like a dolphin circling the gull,  
Who circles the lighthouse  
As my thoughts circle inadvertently."*

- Tribute to Anna Mani by Suniti Namjoshi

In the 1950's when Homi Bhabha was setting up the infrastructure for atomic energy Anna Mani's feminist sensibilities were searching for solar and wind energy. Mani made sterling contributions to the development of meteorology in Independent India.



Anna Modayil Mani was born on 23 August 1918 in Peermedu in Kerala. Her father owned a large cardamom estate. Despite his Syrian Christian ancestry, he was a staunch agnostic. Anna was fond of books and by the time she was twelve she had lapped up just about every book in the local library. On her eighth birthday she declined a set of diamond earrings and opted instead for the *Encyclopaedia Britannica*.

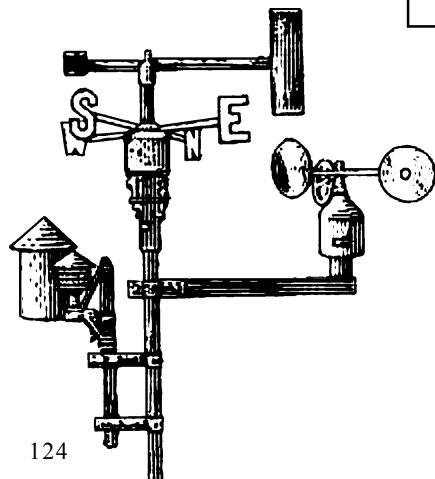
Books opened up a new world and imbued her with a sense of social justice. Gandhi's visit to her

hometown in 1925 had a deep impact on Anna. Instead of marrying early like her sisters she opted for higher education. She wore *khadi* all her life.

Anna wanted to study medicine, but then decided in favour of physics because she was good at it. She took an honours degree in physics from the Presidency College, Madras. During her college days she was drawn to socialist ideas. In 1940, she won a scholarship to do research at the Indian Institute of Science, Bangalore under C. V. Raman. Here she worked on the spectroscopy of diamonds and rubies recording their fluorescence, absorption etc. She had to expose photographic plates for 16-20 hours so she often slept in the lab! She wrote five research papers on the luminescence of diamonds. In 1945 she submitted her PhD dissertation to the Madras University. As she lacked a master's degree she was denied the PhD which she so rightly deserved. Fortunately, the lack of a paper PhD never deterred her.

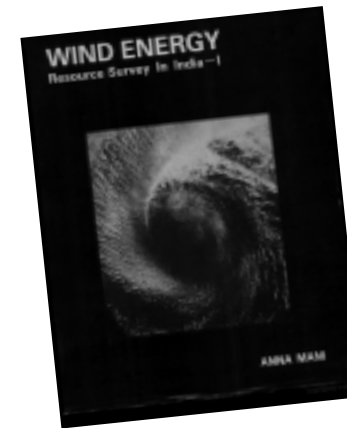
Subsequently, she was awarded a government scholarship for an internship in England. In 1945, Anna Mani went on a troop ship to the Imperial College, London to pursue physics, but landed up specializing in meteorological instrumentation. Here she studied weather instruments, their calibration and standardization procedures.

In 1913, the year of Mani's birth, the literacy rate for women in India stood at less than 1 percent. The total number of women enrolled in colleges was less than one thousand. Even in 1930, when Mani went to college, opportunities for women to pursue science were very limited. There was a consensus at that time that education for women should be tailored to their particular roles as mothers and homemakers.



Independent India offered ample opportunities and Mani seized the challenges. In 1948, she joined the Indian Meteorology Department (IMD) at Pune in the Instruments Division then headed by S. P. Venkiteshwaran, a visionary with boundless energy. Before 1947, even simple meteorological instruments like thermometers and barometers

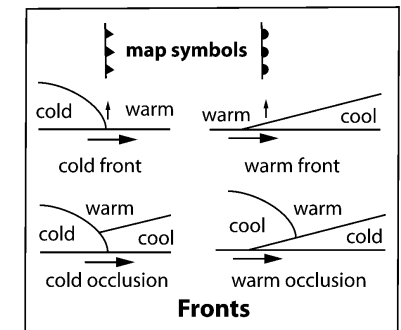
were imported. Being a nationalist Venkiteshwaran wanted to make them in India. He set up a workshop with precision machines to manufacture simple instruments like rain gauges, evaporimeters, thermometers, anemometers, wind vanes etc. He initiated the development of self-recording instruments like thermographs, hydrographs etc. Anna Mani was inspired by all this and wanted to use her newly acquired expertise and her dreams to make India self-sufficient in weather instruments in the shortest possible time.



This was not very easy as skilled human power to operate sophisticated machines was not available. She had to make do with what was available. She inspired the 121 men under her to put in their best. '*Find a better way to do it!*' was her motto. She never compromised quantity for quality. It was a period of intense activity and soon she assembled a core group of Indian scientists and engineers to carry on the task.

Anna Mani standardised the drawings for nearly 100 different weather instruments and started their production. She was deeply interested in solar energy as an alternate source for a tropical country like India. However, data on seasonal and geographic distribution of solar energy in India was limited. During the International Geophysical Year (1957-58) she set up a network of stations in India to measure solar radiation. Initially, only imported equipment was used but soon Mani undertook the design and manufacture of a whole range of radiation instruments.

Mani believed that wrong measurements were worse than no measurements. She insisted on proper design and accurate calibration of all apparatus. In 1960, she started studying *ozone* – when the word was not so famous. The vital role played by ozone in shielding all life forms on earth came to light only two decades later! She undertook the development of an apparatus to measure ozone – *ozonesonde*. This enabled India to collect

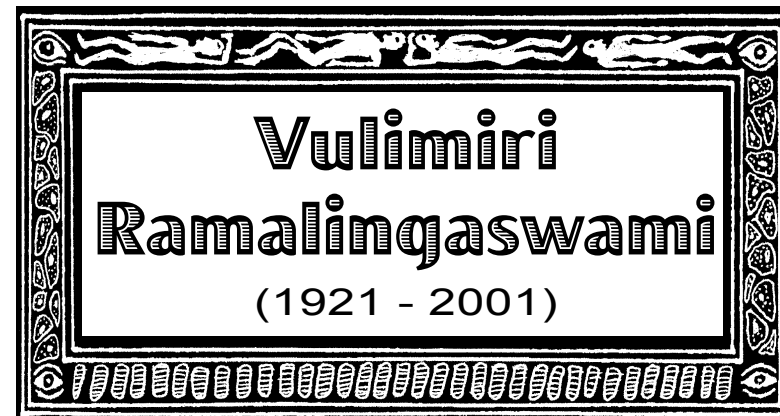


very reliable data on ozone. Because of Mani's singular contribution she was made a member of the International Ozone Commission.

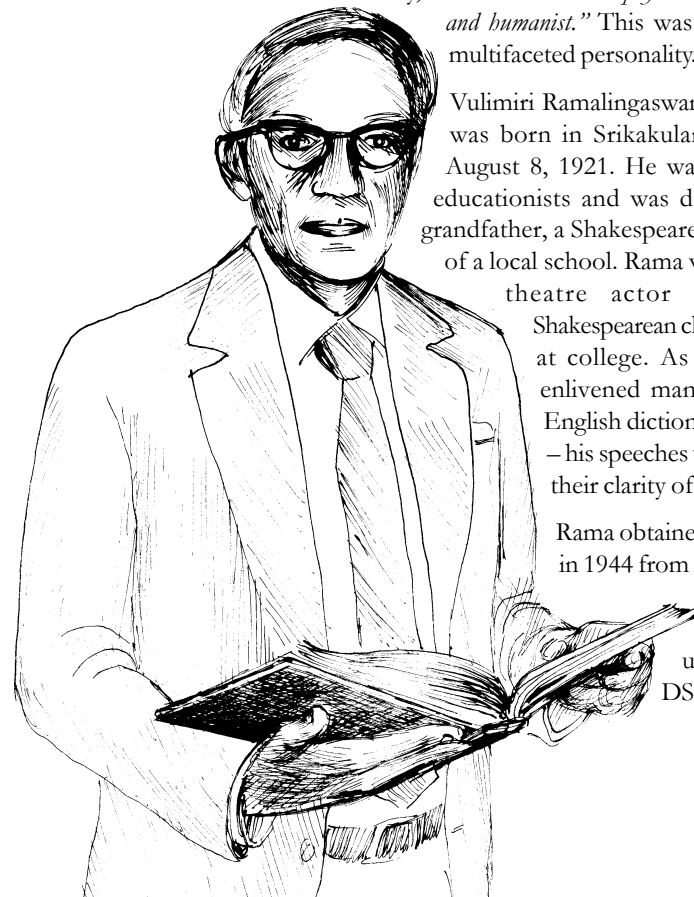


In 1963, at the request of Vikram Sarabhai she successfully set up a meteorological observatory and an instrumentation tower at the Thumba rocket launching facility. Anna Mani retired as the Deputy Director-General of Indian Meteorological Department in 1976. Later she set up a millimetre-wave telescope at Nandi Hills, Bangalore. Her two books *Handbook of Solar Radiation Data for India* (1980) and *Solar Radiation over India* (1981) have become standard reference guides for engineers engaged in solar thermal systems. As a visionary she realized the wind energy potential for India and organized round the year wind measurements from over 700 sites using state-of-art equipment. Today as India takes a lead in setting up wind farms across the country, part of the credit goes to Anna Mani.

For several years Mani headed a small private enterprise in Bangalore which manufactured instruments for measuring wind speed and solar energy. Mani never married. She was passionate about nature and loved trekking, and bird watching. She was a member of many scholarly academies – Indian National Science Academy, American Meteorological Society, and the International Solar Energy Society etc. She received the INSA K. R. Ramanathan Medal (1987). In 1994 she suffered from a stroke which left her immobilised for the rest of her life. She passed away on 16 August 2001 in Thiruvananthapuram.



While honouring Professor Vulimiri Ramalingaswami with the prestigious Leon Bernard Foundation Award, Sir Harold Walter, President of the 1976 World Health Assembly, described him as "*physician, research scientist, teacher, and humanist.*" This was a true reflection of his multifaceted personality.



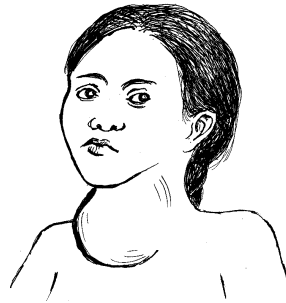
Vulimiri Ramalingaswami – *Rama* to his friends was born in Srikakulam, Andhra Pradesh on August 8, 1921. He was born into a family of educationists and was deeply influenced by his grandfather, a Shakespearean scholar and principal of a local school. Rama was an excellent amateur theatre actor and depicted many Shakespearean characters when he was still at college. As an excellent singer he enlivened many assemblies. His good English diction stood him in good stead – his speeches were truly remarkable for their clarity of expression.

Rama obtained his first medical degree in 1944 from Andhra Pradesh, his MD in internal medicine in 1946 from the same university, a DPhil and DSc respectively in 1951 and

1967 from Oxford, UK. His research career started at the Nutrition Research Laboratory, Coonoor in the Nilgiris (now the National Institute of Nutrition, Hyderabad) in 1947 and extended over the next six decades.

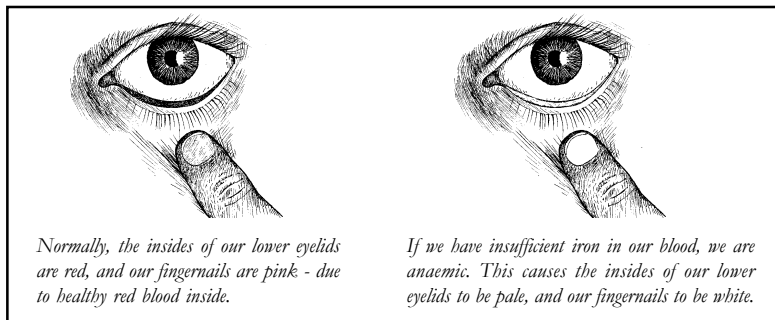
Rama wanted to understand the causes of diseases prevalent in poor countries and use research to better the human condition. His humane approach consisted of a synthesis between laboratory, clinical and community-based medical research. He did original research on protein-energy malnutrition, iodine deficiency disorders, nutritional anaemia, and liver diseases in the tropics. He was interested in primary health care, infectious diseases, and health research for development. His personal commitment and leadership succeeded in providing nutritional protection to millions of refugees during the great Bihar famine of 1967 and the Bangladesh War of 1970-71.

A large incidence of goitre (swelling of the neck due to thyroid problems) led him to conduct a classic experiment in public health. It involved a population of over 100,000 people in the Kangra Hill. Consumption of iodized salt led to a drastic reduction in the disease. This work laid the foundation for the National Iodine Deficiency Control Programme and provided protection to nearly 300 million people!



Ramalingaswami successfully introduced 'iron' supplements in the diet of pregnant mothers. This single measure led to a significant improvement in the health of women and children worldwide.

His other major contribution was the discovery of a new syndrome of liver disease known as Indian Childhood Cirrhosis (ICC).



Although it was well known that deficiency of vitamin A caused night blindness, he was the first to demonstrate the actual damage of the rods and cones of the retina of new born monkeys, following maternal deficiency of vitamin A.

When the All India Institute of Medical Sciences (AIIMS) was being founded there was a search for good faculty. Ramalingaswami was the obvious choice for the position of Professor of Pathology at AIIMS. Soon, he became the departmental head. This gave him a rare opportunity to develop an excellent school of pathology. He inspired an array of brilliant students who spread his name and fame throughout the world.

During this period at AIIMS, Ramalingaswami made a major contribution by fostering scientific interaction between Indian and eminent pathologists of the West. The list is a veritable who's-who of the world's most eminent



pathologists - Drs Benjamin Castleman of Harvard, Walter Putschar of Harvard, Hans Popper of Montefiore Hospital, Dame Sheela Sherlock of the Royal Free Hospital, London, and others delivered advanced lectures on different aspects of pathology. Later Prof Ramalingaswami became the Director of the AIIMS, a post he executed with great finesse and which won him accolades both from the faculty and the Government.

He played a key role in laying the foundation of the Indian Council of Medical Research (ICMR) and was appointed its Director General in 1979. During his 7 year tenure at the ICMR he enlarged its activities in many directions. Apart from setting up new institutions, he developed the concept of Regional Medical Research Centres for tackling local health problems in specific and far-flung areas. He greatly contributed to the reorganization of ICMR especially through introduction of a rigorous peer review system for all research programmes. The mechanisms that he laid down were of an enduring nature and are still being practiced.



With his clinical moorings, he envisaged the need for epidemiological studies in the country. He initiated the idea of an Indian Registry of Diseases with an integral statistics division. Later, these concepts fructified in the form of the Statistical Unit at ICMR.

He always responded creatively to a national crisis or an emergency. A notable example was the manner in which he mobilized and organized resources and human power

for conducting scientific studies in the wake of the Bhopal Gas disaster. He also actively helped during the outbreak of plague in Surat.

Even after retirement Prof. Ramalingaswami's skills were keenly sought by International agencies. He was invited as a Fogarty Fellow and later as a Special Professor of Toxicology at Harvard. Subsequently, he assisted UNICEF for a period of 5 years. He was actively associated with national bodies like the Rajiv Gandhi Foundation, Cancer Research Institute, Centre for Science and Environment and the Ranbaxy Foundation. Till the very end of his life – May 8, 2001, he worked as a National Professor at the AIIMS, New Delhi.

Prof. Ramalingaswami was amongst the most honoured Indian medical scientists. He received both the Bhatnagar and the Padma Bhushan awards. He was a Fellow of the Royal Society, Fellow of all the three National Academies of Sciences in India (President of the INSA – 1979-80), Fellow of the National Academy of Medical Sciences, Foreign Associate of the US and Russian Science Academies and Fellow of the Royal Colleges of Physicians and Pathologists. He was awarded a DSc by the Karolinska Institute, Sweden. He was also Chairman of the Global Advisory Committee on Medical Research to the World Health Organisation.

Prof Ramalingaswami was also blessed with a happy family. His wife Surya Prabha retired as a Professor in the Centre for Social Medicine and Community Health from the Jawahar Lal Nehru University, New Delhi. His son Dr. V. Jagadish is currently Chairman of the voluntary agency *South Asia against AIDS* based in Bethesda, Maryland and daughter, Dr. Lakshmi works at the Mount Sinai Hospital, New York.



*Ramalingaswami investigated the extent and cause of toxicity in the world's worst industrial disaster, in which the negligence of Union Carbide (now Dow Chemical Co.) killed and injured thousands of people in Bhopal.*

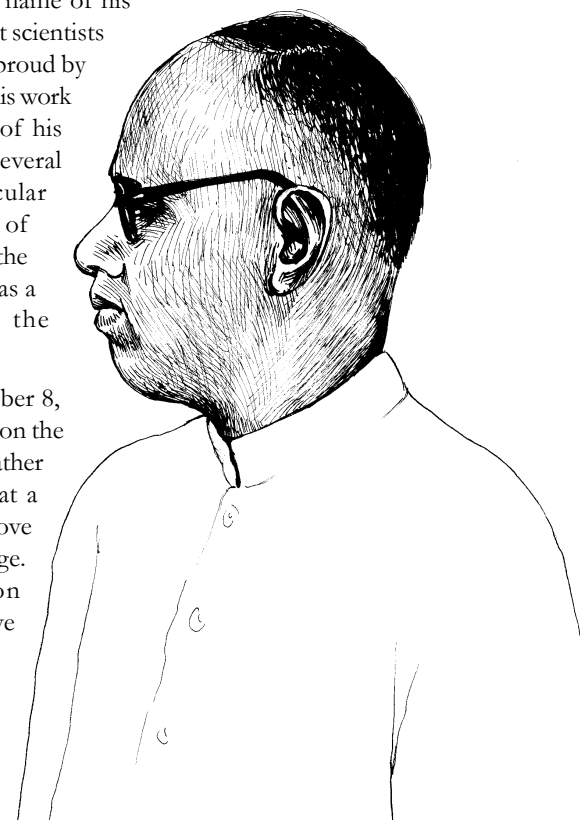


*"If you think you know it, then you do not know it, and if you know that you cannot know it, then you know it".*

– G. N. Ramachandran

G. N. Ramachandran ('G' stands for Gopalasamudram, his native town, and 'N' stands for Narayana Iyer, the name of his father) was one of the most brilliant scientists of the 20th century who did India proud by his research. Ramachandran did all his work in India following the footsteps of his mentor C.V. Raman. He made several important discoveries in molecular biophysics, especially in the study of protein structure. His discovery of the *triple helical* structure of collagen was a fundamental advance in the understanding of peptides.

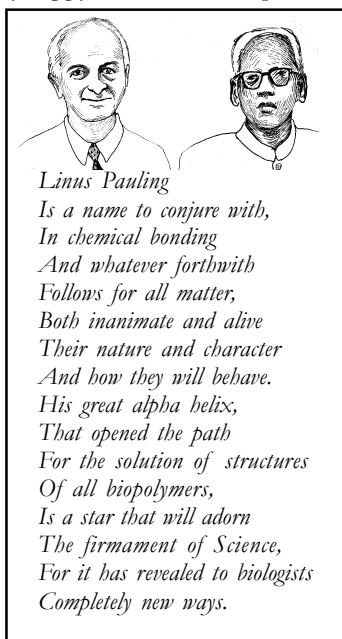
Ramachandran was born on October 8, 1922, in a small town near Cochin, on the south-western coast of India. His father was a Professor of Mathematics at a local college and gave young Ram a love for mathematics at a very young age. He would bring books on mathematics from the library and give



Ram a challenging theorem to prove every day. He would write equations and ask Ram to solve them. So, Ram was quite well versed in advanced maths from his young days. No wonder he got a perfect score of 100 in all his mathematics examinations. Ramachandran graduated in 1942 topping the BSc course of the University of Madras. Among the teachers in St. Joseph's College who stimulated Ramachandran's interest in physics were P.E. Subramaniam and a Jesuit priest, Father Rajam.

His father wanted him to join the Indian Civil Service, but it did not interest him. Later he was packed off to Delhi to appear for the Indian Railway Engineering Service Examination, in which he deliberately performed badly and failed. In 1942, Ramachandran joined the Master's program in Electrical Engineering at the Indian Institute of Science at Bangalore. But he was soon brought into the physics department by Sir C. V. Raman. Within a week of joining Raman gave him Rayleigh's paper and an important problem to solve. Within a day Ramachandran wrote the mathematical equations and worked out a rigorous proof. This made Raman very happy. Under Raman's guidance Ramachandran did post-graduate research in the areas of optics and X-ray topography. Raman was overjoyed by the brilliance of his student.

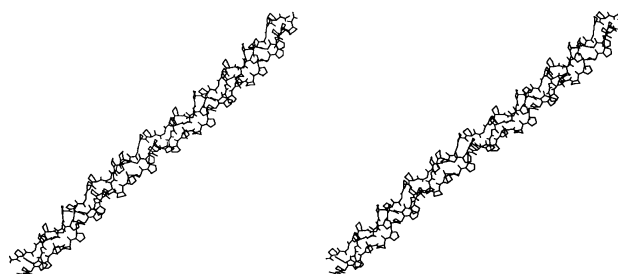
In 1947, Ramachandran went to the Cavendish Laboratory headed by Sir Lawrence Bragg. At Cambridge he worked with W. A. Wooster and H. Lang on crystallography and developed a mathematical theory for determining the elastic constants of crystals from measurements of diffuse X-ray reflections. He received a PhD from Cambridge University in 1949. While in Cambridge, Ramachandran met Linus Pauling and was deeply influenced by his lectures on modelling studies of peptide chains. He even wrote a poem on Pauling (at right).



Ramachandran returned to Bangalore in 1949 and worked as an assistant Professor in Physics until 1952. At that time Sir A. L. Mudaliar, the Vice-Chancellor of the University of Madras and a visionary wanted to start an

experimental physics division at Madras and invited Sir C. V. Raman. Raman declined and recommended Ramachandran for the position. Thus in 1952, Ramachandran became a professor of physics at the University of Madras at a young age of 29. The generous assistance and support provided by Sir Mudaliar enabled Ramachandran to set up a fully equipped modern X-ray crystallographic laboratory at Madras.

Ramachandran concentrated on solving the structure of collagen, the most abundant protein connective tissue. Using collagen samples from kangaroo tail tendon, and assisted by his first post-doc student, Gopinath Kartha, he produced

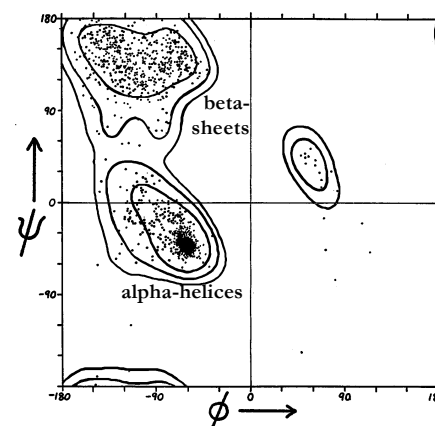


*This is a stereo-view of the molecular structure of the backbone of collagen. If you cross your eyes while looking at it, you should be able to see the structure in 3-dimensions. You can see the three strands of polypeptides that wind around each other to make the helix.*

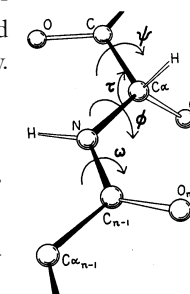
X-ray diffraction patterns from the collagen fibres. Using experimental data they built a ball-and-stick model of collagen structure and published a paper in *Nature* in 1954. Subsequently they revised the model giving rise to the now famous coiled coil structure.

Ramachandran and his colleagues laid the foundations for the analysis of polypeptide chains. They introduced a two dimensional map what is today known in bio-chemical literature as the *Ramachandran plot*, which provide a

rational basis for describing all possible structures of polypeptides. This had a profound impact on stereo-chemistry and structural biology.



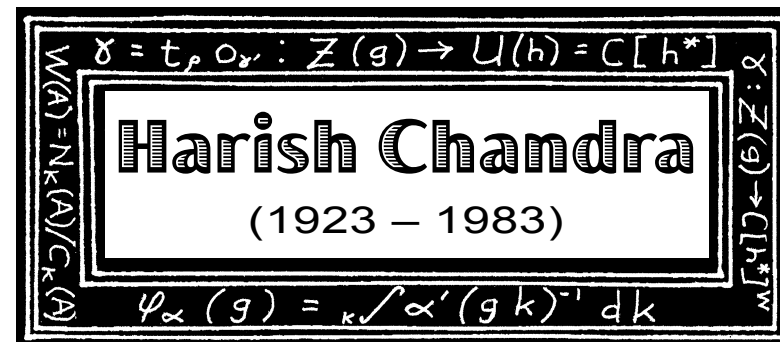
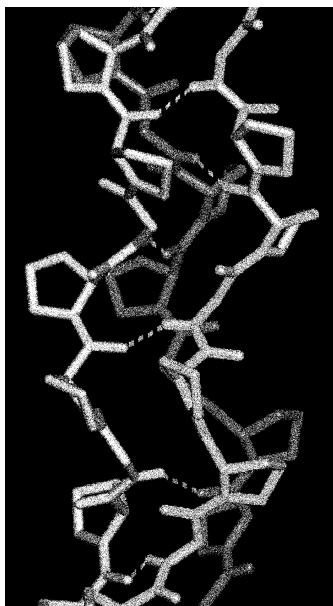
*The Ramachandran plot (left) shows the distribution of peptide torsion angles (right) that determine the 3-dimensional structures of proteins.*



Ramachandran resigned from Madras in 1970 and then spent two years as a visiting professor at the Biophysics Department of the University of Chicago. During this visit he devised a new method to reconstruct three-dimensional images from two-dimensional data, thus laying the foundations of computerized tomography. On his return from Chicago Ramachandran joined the IISc and set up the Molecular Biophysics Unit (MBU). In 1977 he visited the National Institute for Health in Bethesda, Maryland, USA as a Fogarty Scholar. In the same year he was elected a Fellow of the Royal Society, London. He retired from MBU in 1978 but continued as a Professor of Mathematical Philosophy at the IISc until 1989.

From the early 1980's he developed Parkinson's disease and was cared for by his wife Rajam whom he married in 1945. In 1998, Rajam suddenly died of a heart attack and this was a grievous shock from which Ramachandran never recovered. In 1999, the International Union of Crystallography awarded him the 5th Ewald Prize for his outstanding contributions to crystallography. In 1999 he had a cardiac arrest and since then remained in the hospital until his death on 7, April 2001. He is survived by two sons, Ramesh Narayan (Professor of Astrophysics at Harvard University) and Hari (Institute for Plasma Research, Ahmedabad) and a daughter Vijaya (Professor of Computer Science, University of Texas at Austin).

Ramachandran was a man of many talents. He was deeply interested in classical music – Indian and Western as well as the philosophical systems of India and the West. He suffered serious psychiatric problems during most of his adult life. Fortunately they did not impact on his scientific creativity or productivity. Ramachandran was clearly a *Nobel Class* scientist and it is surprising that he was not given any civilian award by the Government of India. Because collagen is the basic component of leather, the Central Leather Research Institute (CLRI) in Chennai has named the building housing its auditorium *Triple Helix* after the triple helical structure of collagen discovered by Ramachandran in 1954.



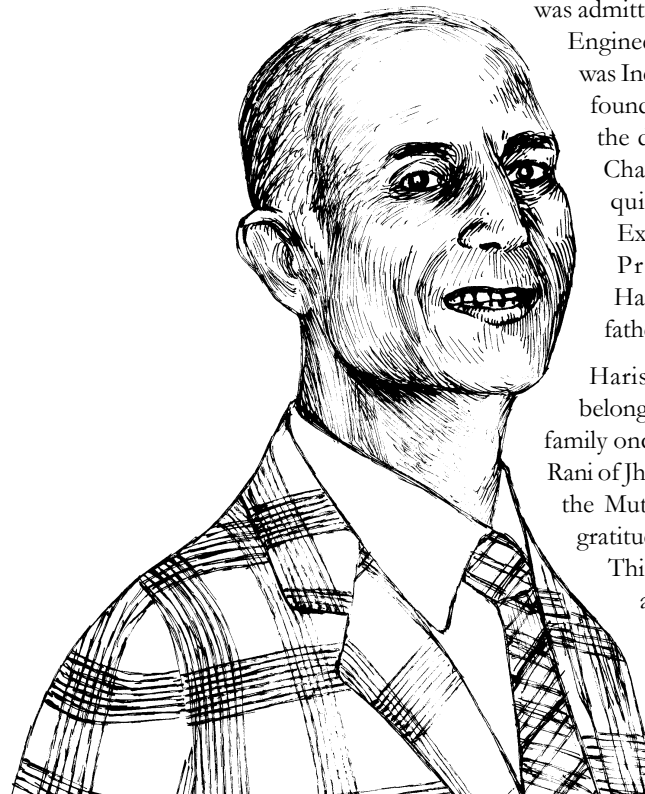
Harish Chandra was an outstanding mathematician of his generation. He was a mathematician who transformed the peripheral topic of 'representation theory' into a major field which became central to contemporary mathematics.

Harish was born on 11 October 1923 in Kanpur. His grandfather was a senior railroad clerk in Ajmer. He was deeply committed to give his son Chandrakishore a good education. To finance his education he resigned his post and collected the lump sum given as severance pay. Later he rejoined the railroad thereby losing his seniority in the service hierarchy. Chandrakishore - Harish's father was admitted to the premier Thomason

Engineering College in Roorkee. It was India's first Engineering College founded to train civil engineers for the department of public works. Chandrakishore eventually rose quite high and retired as the Executive Engineer of the Uttar Pradesh Irrigation Works. Harish often accompanied his father on long tours to canal sites.

Harish's mother Satyagati Seth belonged to a zamindari family. The family once gave refuge to the ill-fated Rani of Jhansi - the central figure during the Mutiny of 1957. As a token of gratitude she left behind her sword.

This souvenir was highly prized as a family heirloom! Harish



spent most of his childhood in his maternal grandfather's house. He was precocious in studies but often ill. Being timid he was endlessly teased by his classmates. Harish imbibed a life long love for classical music in his grandfather's house. Harish's elder brother Satish joined the elite Indian Civil Service and rose to become the top bureaucrat in independent India.

Chandra completed his initial education in Kanpur. As a very bright student in his MSc Physics class at Allahabad University, he solved the theory of the vibration of the *mridangam* on the spot, with Prof. C. V. Raman as the examiner and received 100% marks for it. In the Allahabad University, K. S. Krishnan, encouraged Chandra in every possible way and recommended him as a research student to Homi Bhabha at the Indian Institute of Science, Bangalore. Raman's fame was at its peak and it is no wonder that the young Chandra chose to study not mathematics but theoretical physics. Chandra's French teacher at the Allahabad University Mrs. H. Kale had become the librarian at IISc. So he stayed with her in Bangalore. Later Chandra married Lalitha - Mrs. Kale's daughter.

Bhabha recognized the genius in Chandra and sent him off to study with Dirac. In 1945, Chandra as a student of Dirac at the University of Cambridge realised his true inclination and switched over from physics to mathematics. While at Cambridge he attended Wolfgang Pauli's lectures, and during one, pointed out a mistake in Pauli's work. Thereafter the two became life-long friends. He obtained his PhD in 1947 on the *Infinite irreducible representations of the Lorentz's group* and during the same year he moved to the USA. Almost

immediately upon his arrival at the Institute for Advanced Studies, Princeton, Chandra began working at a ferocious pace setting standards that the others could only admire but never emulate. When Dirac visited Princeton, Harish-Chandra worked as his assistant.

Chandra was influenced by the mathematicians Herman Weyl and Claude Chevalley. He spent 13 years 1950 to 1963, at the Columbia University carrying out some of his best research using formidable and inductive logic. He worked with Armand Borel and founded the theory of arithmetic groups.

From 1968, until his death in 1983, he was IBM von

Neumann Professor in the School of Mathematics at the Institute for Advanced Study, Princeton.

He was a man who kept no useless papers, and used the back sides of his manuscripts for scrap work. His lectures which usually comprised of his own course work were very sought after. These lectures gave students a feel of the way a mathematician thinks and his struggles. Chandra always thought of himself as an outsider, perhaps because he came to mathematics late. He was a great admirer of two other great outsiders, the impressionists Cezanne and Van Gogh, seeing himself in them. Chandra had himself been an enthusiastic and talented painter in his youth.

In the last years in India and England, Harish-Chandra was busy with relativistic field theory. His ideas have since found their way into several texts. Harish-Chandra's achievements as a mathematician were great. The theory he created still stands like a Gothic cathedral, heavily buttressed below but, in spite of its great weight, light and soaring in the upper reaches, coming as close to heaven as a mathematician can. He believed mathematics as a medium to mediate between man and what can only be called God. In this his task was not to bring men closer to God, but God closer to men.

Harish-Chandra was a Guggenheim Fellow in 1957-58 and a Sloan Fellow from 1961 to 1963. He was elected a Fellow of the Royal Society in 1973. He was elected Fellow of the Indian Academy of Sciences and the Indian National Science Academy in 1975 and of the National Academy of Sciences of the USA in 1981. He was an Honorary Fellow of the Tata Institute of Fundamental Research, Bombay. He was awarded honorary degrees by the Delhi University in 1973 and the Yale University in 1981. He received the Cole Prize of the American Mathematical Society in 1954 and the Srinivasa Ramanujan Medal of the Indian National Science Academy in 1974. The Indian Government honoured him by naming an institute dedicated to Theoretical Physics and Mathematics, after him, in Allahabad, India. The institute is known as Harish-Chandra Research Institute or HRI.



He died of a heart attack in 1983, during a conference in Princeton in honour of Armand Borel's 60th birthday. A similar conference in his honour, scheduled for the following year, was not to take place. He is survived by his wife, Lalitha, and his daughters Premala (Premi), and Devaki.



# A. S. Paintal

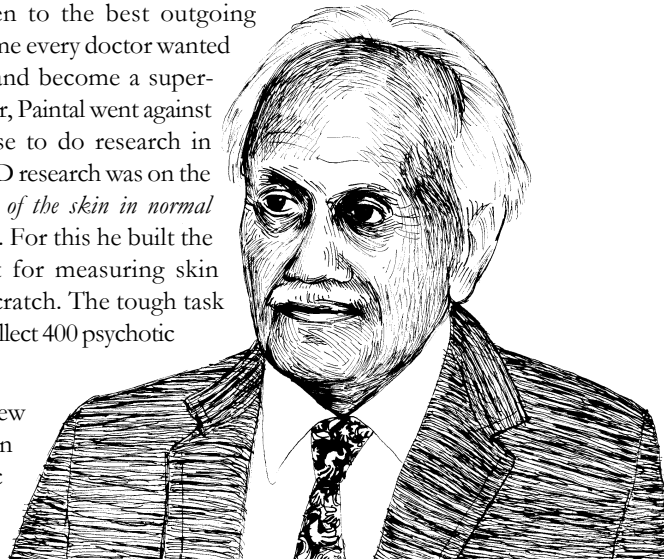
(1925 – 2004)

Autar Singh Paintal was perhaps India's best known physiologist. He was a prodigious researcher with a very colourful and uncompromising personality.

Paintal was born on 24 September 1925 in Mogok, Burma where his father worked in the British Medical Service. He completed his Matriculation from Lahore at the age of fourteen and later joined the Forman Christian College for his Intermediate. Later he joined his parents who by then had settled in Lucknow. He joined the King George's Medical College, Lucknow in 1943, with financial help from the Burmese Government.

Paintal had an extraordinary intellect and received several awards while doing MBBS including the much coveted Hewitt Gold Medal given to the best outgoing student. At that time every doctor wanted to treat patients and become a super-specialist. However, Paintal went against the tide and chose to do research in physiology. His MD research was on the *Electrical resistance of the skin in normal beings and psychotics*. For this he built the entire equipment for measuring skin resistance from scratch. The tough task however, was to collect 400 psychotic patients!

He introduced a new index for evaluation of human galvanic



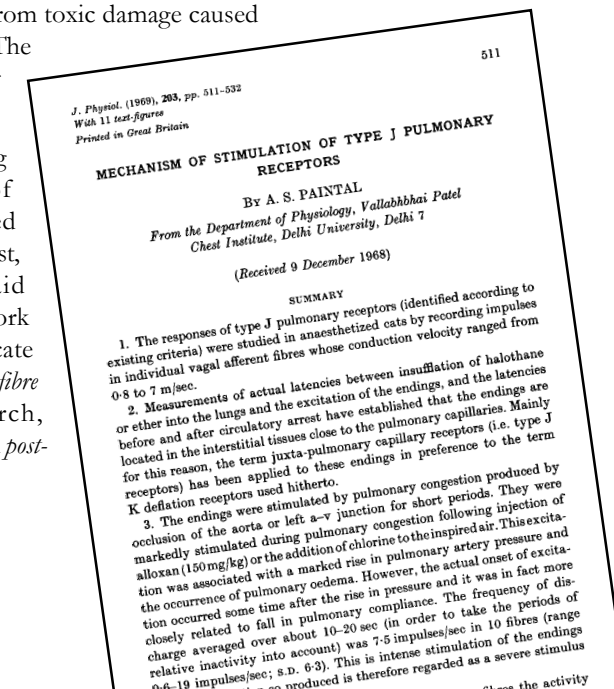
response. This was known as the *Paintal Index* and was used by clinicians in the early days. He continued in his alma mater and later became a lecturer in the Department of Physiology.

Later he received a Rockefeller Scholarship to pursue PhD from the Medical School in Edinburgh. Here he conceptualised the discovery of *J-receptors*. At that time it was difficult to dissect single nerve fibres without impairing their activity. He found an innovative method of dipping the whole nerve in liquid paraffin to embed the whole nerve and isolate the single fibres without impairing their activity. This gave a tremendous boost to research in this area.

In 1953 he returned to India and joined the Defence Laboratory in Kanpur. After five years he moved to the All India Institute of Medical Sciences (AIIMS), New Delhi as a researcher in Physiology. Six years later he became the Director of the V. P. Chest Hospital a post he held till 1990. Later even when he became the Director General of the Indian Council of Medical Research (ICMR) he still continued his research at his modest two-room laboratory at the V.P. Chest Institute.

Paintal is best known for the discovery of *J-Receptors* – a word he coined and researched in-depth. It was well known that the heart and lungs have a rich network of fibres which send signals following chemical or mechanical changes in the local environment. Paintal was the first to show that *J-Receptors* were responsible for the reflex action, which acted as a feedback mechanism to limit muscle activity during exercise. Such negative control was necessary for protecting the muscles from toxic damage caused during physical exercise. The discovery of *J-Receptors* was hailed world-wide.

Paintal was ranked among the best in his field of research. The celebrated cardio-vascular physiologist, Prof. C. Heymans paid glowing tributes to his work and went on to demarcate two distinct periods in *fibre action potential* research, namely, *pre-Paintal* era and *post-Paintal* era!



Paintal continued further investigations on various aspects of *J-Receptors* including high altitude physiology and breathlessness caused by exertion. This research threw new light on the acclimatization of Indian soldiers posted to high altitude Himalayan regions.

The halo around high-sounding administrative positions never attracted him. He was more at home in his laboratory where he delved deep into several areas of interest. Paintal's interest in science was more than that of a genuine researcher. He was deeply concerned with ethical issues in the practice of science and founded the Society for Scientific Values (SSV). A large number of young and old scientists were attracted to it. This team investigated cases of malpractice or fraud with vigour and spent their time and money in the pursuit of truth. Today its advice is sought by many leading organizations and individuals. Paintal's high ethical standards were often misinterpreted by peers. He refused to attend inaugurations or meetings in hotels. He felt that science meetings should be held in the academic environs of the university and it hurt him when they were held in five-star hotels. He never visited tainted institutes even if they wanted to confer an honour on him! These sterling ethical qualities did not endear him and he was easily termed an eccentric.

His students often found him deeply absorbed in repairing some scientific apparatus in the lab – a rare sight for an Indian scientist! His high standards of integrity were hard to emulate. He strongly felt that research work should not be imitative and one should contribute something original to the existing body of knowledge. Paintal believed that *'Dependence on other people's labours was doing research by piracy'*.

Besides physiology and research, his only known hobby was yachting, which he did on the Yamuna River before it turned into a sewer.

His lectures were in a narrative mode and were peppered with innumerable experiences, episodes, anecdotes and scientific debates. This style exasperated the conventional students who expected knowledge to be packaged in neatly ordered quanta! However, the initiated students found his style deeply inspiring - laced with the excitement of discovery. He adhered strongly to his principles



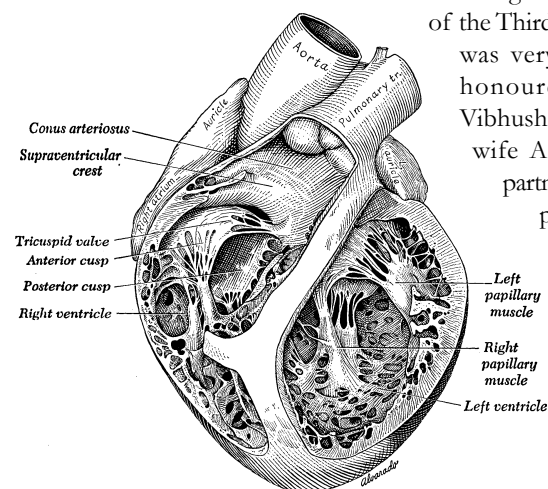
of right and wrong and saw no reason to change them in the interest of pragmatism or societal approval.

During his research career spanning well over five decades Paintal published nearly 400 papers. His research had a major 'influence' on biomedical science; and his contribution to physiology is overwhelming. His papers were cited and quoted by many researchers. Until 2004, his papers were cited as many as 3672 times - a very high Science Citation Index for any researcher. However, he did not think it was right to assess a scientist on the basis of their number of publications and citations. He explained that *"It undermines the far more useful work in more urgent fields (such as leprosy, of no value to the West). It is, therefore, only fair that such scientists are assessed on the basis of other criteria such as usefulness of their work to Indian S&T [Science and Technology] and social value."*

In an era when scientists the world over were fast switching to scientific disciplines, which fetched more funding and public glory, Paintal continued to work in the unfashionable area of physiology.

Many honours came his way. Paintal was elected to the Fellowship of the Royal Society of London (1981) and Edinburgh (1996). He was President of the Indian National Science Academy and the General President of the Indian Science Congress. He was the Founder Member

*"Compared to the dynamic first half of the 20th Century, the intellectuals of the second half look like 'lotus eaters', interested in, and promoting, a comfortable existence, secure jobs with attractive perquisites and ostentatious lifestyles with no aim or desire to achieve anything in particular. .. We have given up self-reliance as a driving force. We are back to subservience of a different kind - technological subservience... There is no question of self-help."*  
-A.S. Paintal. 1985



of the Third World Academy, whose cause was very dear to him. The country honoured him with the Padma Vibhushan in 1986. He is survived by wife Anand who was his life-time partner in research. He was simplicity personified, modest to a fault, and carried his greatness lightly on his shoulders. This great medical researcher passed away in Delhi on 21 December 2004.



Prof. Ashesh Prasad Mitra did pioneering work on the ionosphere and climate change and wore with distinction the mantle of his guru Prof. Sisir Kumar Mitra, FRS.

A. P. Mitra was born on 21 February 1927 in Calcutta where he received his early education. He learnt high standards of academics and discipline from his school teacher father. These values Mitra nurtured and actively practised throughout his life. Being a bright student he always topped his class. After an MSc in physics from the University of Calcutta he joined the laboratory of



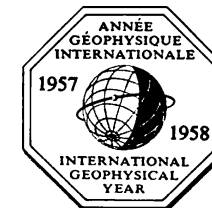
Prof. S. K. Mitra, FRS and pioneer of ionosphere research in India. This one decision propelled him into a glorious career in science.

In 1954, after finishing DPhil from Calcutta University, Mitra joined the National Physical Laboratory (NPL), New Delhi. There he founded the new division of Radio Science and was closely associated with it till his very end. The development of Radio Science was closely linked with the study of the ionosphere - a region in the upper atmosphere that

reflects short radio waves enabling transmission around the curved surface of the earth. Before the advent of rockets these far reaches of the atmosphere were difficult to access. Whatever little information we had about the ionosphere was collected indirectly through spectroscopy or other earth based instruments. Prof. S. K. Mitra laid the foundation for ionosphere research in India. His long-term associate and successor Prof. A. P. Mitra carried the programme forward.

Research on the ionosphere has always depended largely on the prevailing technology. In the sixties the upper atmosphere was probed using rocket-borne payloads. In the seventies the Satellite Instructional Television Experiment (SITE) used radio beacons to study the upper ionosphere. Balloons and rockets were used extensively in the eighties to elicit data of this far away region. In the nineties satellites in conjunction with radars, studied the atmosphere from the earth's surface to heights of 1000 km. Physical properties like density and temperature were measured at various levels along with a host of other parameters. Mitra, co-ordinated and oversaw all these successful developments.

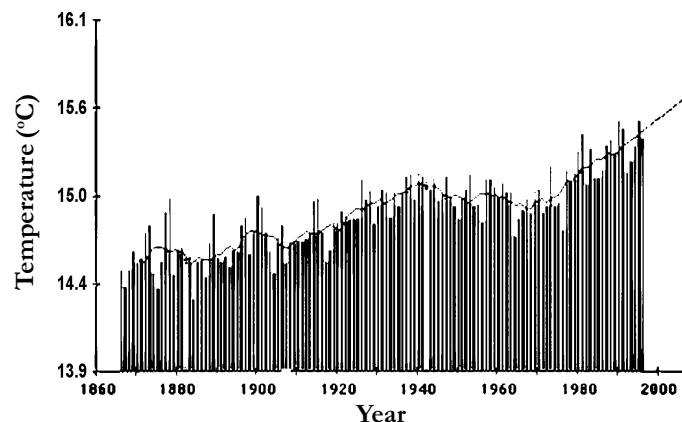
Mitra was the driving force of the Indian programme of the International Geophysical Year (IGY), 1957-58 and the International Quiet Sun Year (IQSY), 1964-65.



In the 1970s, Mitra introduced radio research in the tropo-sphere region which contributed significantly to India's radio communication capability. He established an International Radio and Geophysical Warning Centre to alert India, Middle East and South East Asia about potential earthquakes and also an extensive radio flare detection system.

Known to be assertive, Mitra combined the qualities of a good administrator and a scientist in his tenure as director of the NPL (1982-86) and director general, CSIR (1986-91). He headed India's Monsoon Asia Integrated Regional Study programme.

During the nineties Mitra concentrated his efforts on understanding the global environmental changes wrought by human activities and their consequences on the biosphere. His landmark contributions in studying the ozone layer, atmospheric chemistry and measuring greenhouse gases in India had an international impact. In the early 1990s, the US Environmental Protection Agency blamed Indian paddy fields of emitting 38.6 million tonnes of methane per year and thus adding substantially to global warming. Mitra called it a lie



Global warming is shown in this graph of global yearly temperature.

and showed that Indian rice fields emitted only four million tonnes of methane per year! The fact remains that the West contributes 9 times more per capita to global warming as compared to India. He warned about the pollution being caused by coal and the diesel burning generators used in shops, houses and agricultural pump-sets.

He wanted to counter climate science eco-politics by good home grown science. He felt that most foreign funded agencies manipulated research data to suit narrow national interests. So he was keen on setting up a South Asian Association for Regional Cooperation (SAARC) network for collecting data on pollution and climate change with India in the lead. He suggested the setting up of a series of labs in various regions for studying atmospheric data. He wanted to rope in the army too, in this data collection, especially in the rugged, remote and high altitude regions of the Eastern Himalayas which were not accessible to scientists. He believed that sound policies could only be based on good quality and authentic data. He felt that the Intergovernmental Panel on Climate Change (IPCC) was far behind in its research and stressed that India should do sustained research on emissions and get its act right on the climate issue.

Mitra along with 200-odd scientists from India, Europe, Maldives and the US conducted an intensive six-week field experiment in 1999 to study the effect of airborne tiny particles called *aerosols* on the climate. Mitra was one of the three chief scientists of the Indian Ocean Experiment (INDOEX). The venue of

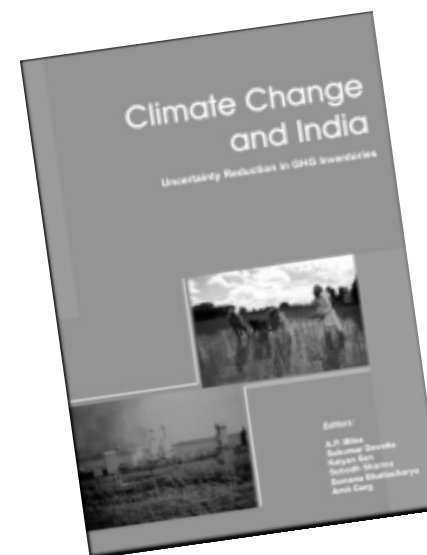
the study was the Indian Ocean – where clean air from the Antarctica met the not-so-clean air from the Indian subcontinent providing a unique natural laboratory to study this phenomenon. They found a thick haze roughly seven times the size of India enveloping the north Indian Ocean. This haze could seriously affect rainfall and the onset of monsoon through its influence on cloud formation. Mitra warned that aerosols could affect agricultural yields, cause asthma and change rain patterns.

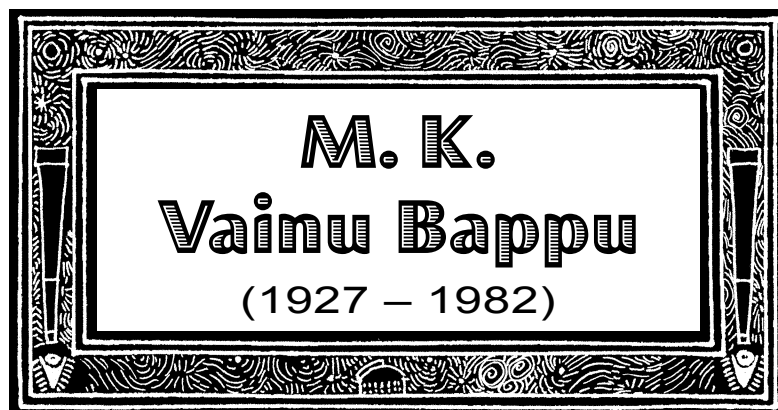
Mitra stressed the need for conserving water and did not rule out future water-wars between nations. He was extremely critical of short-sighted policies which promoted water guzzling crops like sugarcane in water deficient areas.

He wrote over 200 scientific papers and edited several books and monographs. To mention a few: *Advances in Space Exploration* (1979) (ed.); *Ionospheric Effects of Solar Flares*; *Human Influences on Atmospheric Environment*. He was on the editorial board of several scientific journals including *Journal of Atmospheric and Terrestrial Physics*, *Space Science Reviews*, *Indian Journal of Radio and Space Physics* and *Mausam*.

Mitra received many awards including the Shanti Swarup Bhatnagar Award for Physical Sciences (1968) and the Padma Bhushan (1989). He was elected Fellow of Royal Society of London (1988) and was a member of many distinguished scientific academies.

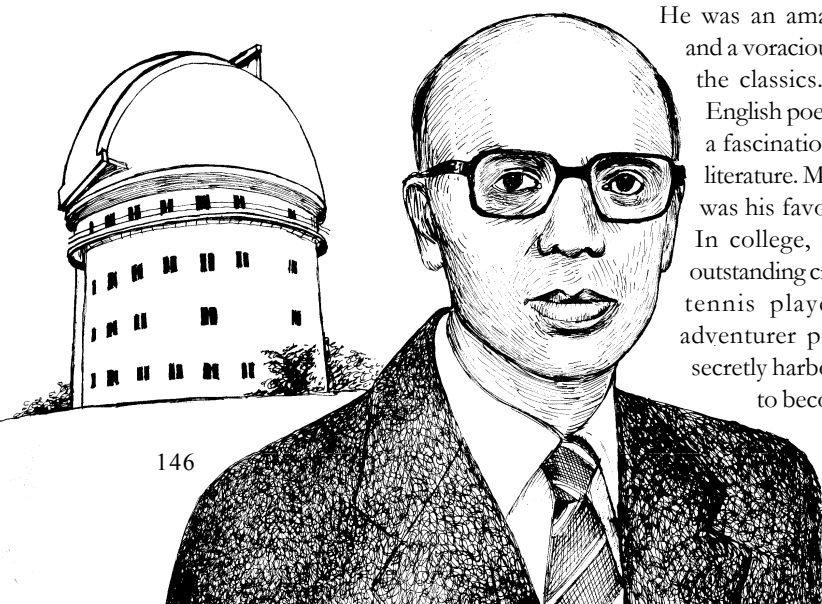
Mitra who carried forward India's post-independence vision of using science for development, died in New Delhi on September 03, 2007 at the age of 81. He was survived by his wife, Sunanda Mitra, two daughters, and two granddaughters.





Vainu Bappu was singularly responsible for weaving the warp and weft of modern astronomy research in India. His untiring efforts created the necessary infrastructure for future astronomical research in India.

Vainu Bappu was born on August 10, 1927. His family hailed from Cannanore but his father worked in the Nizamiah Observatory, Hyderabad. So, Vainu had his school and college education in Hyderabad. His gift for oratory won him widespread admiration in school. In college he organized the science club and edited the college magazine. As the secretary of the College's Physics Association he actively organized popular science lectures. In 1943, when Sir C. V. Raman delivered a series of lectures in Hyderabad, Vainu bicycled 16 km, every day each way and did not miss a single lecture!

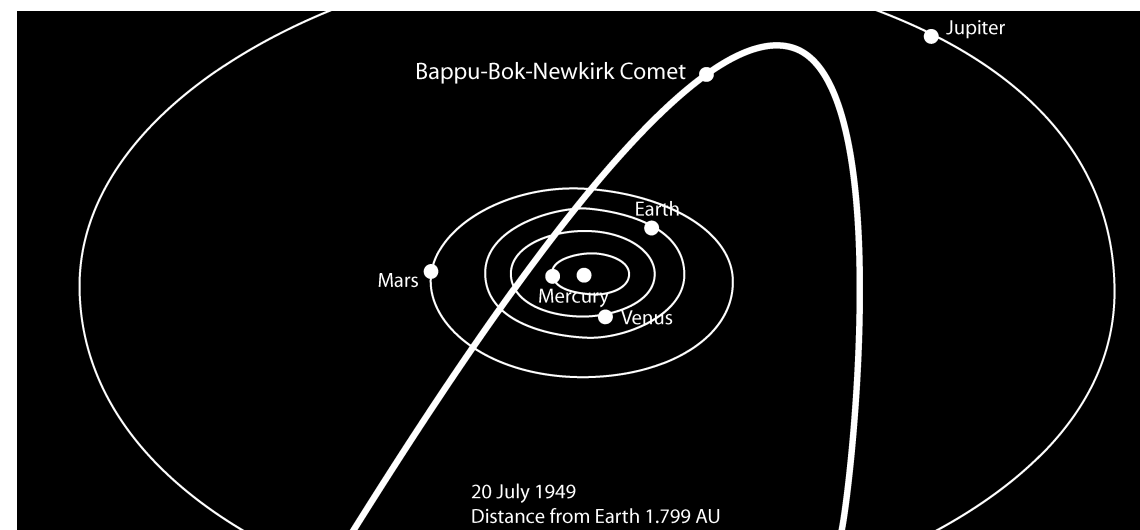


He was an amateur artist and a voracious reader of the classics. He loved English poetry and had a fascination for Urdu literature. Mirza Ghalib was his favourite poet. In college, he was an outstanding cricketer and tennis player. As an adventurer perhaps, he secretly harboured a yen to become a pilot.

His favourite book was *The Spirit of St Louis* – the immortal saga of Charles Lindbergh. Vainu had a deep admiration for Homi Bhabha both as a scientist and artist. Vainu's artistic bent is on display in the canvasses and gardens in the various observatories he inspired.

Vainu was exposed to telescopes at the Nizamiah Observatory as a child. The wonders of the night sky fascinated him from early childhood. In college he built a spectrograph, for which he exposed the 'sensitive plate' for six nights in a row from his bedroom window and published his first scientific paper in 1946.

In 1948 after finishing MSc he wanted to pursue a career in astronomy but there were few opportunities in India. As luck would have it, Sir Harold Spencer Jones, Astronomer Royal, UK and Professor Harlow Shapley of Harvard University were visiting India. Vainu met them in Hyderabad. Shapley had read about Vainu's work as an amateur astronomer. With Shapley's efforts Vainu went to Harvard University in 1949 on a Government of Hyderabad scholarship. At Harvard, Vainu found himself in the company of very capable and inspiring people. Within a few months of coming to Harvard, Vainu discovered a comet. While viewing a routine sky picture on a photo plate he noticed something unusual. With his colleagues he discovered a new comet which was named Bappu-Bok-Newkirk after its discoverers. Bappu was awarded the Donohoe Comet Medal of the Astronomical Society of the Pacific for this discovery.



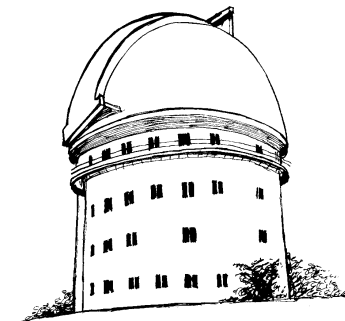
After his PhD in 1951, Bappu was the first Indian to be offered the prestigious Carnegie Mellon Fellowship in astronomy. This enabled him access to the world's biggest 200-inch Mount Palomar telescope. Here he investigated challenging problems of stellar spectroscopy. His exhaustive study of Wolf-Rayet stars made him a world authority on the subject.

In 1953, Bappu returned to India where facilities for astronomy research were primitive and the biggest telescope available was just a 15-inch refractor! In 1954, he joined the Uttar Pradesh Observatory at Varanasi as a Chief Astronomer. He was able to convince the state chief minister to shift the observatory to a better location. Bappu scouted a better site on a hill near Nainital. Here within a few years he trained a team of young and highly motivated astronomers who later contributed enormously to the growth of astronomy.

In 1960, at the behest of the Government of India, Bappu became the youngest director of the 170-year old Kodaikanal Observatory. The British East India Company set it up in 1792 at Madras and shifted it to Kodaikanal in 1899. Illustrious astronomers like N. R. Pogson and John Evershed of *Evershed Effect* fame had been earlier directors of this institute. Bappu set up an instrumentation and optics workshop where several small telescopes and spectrographs were constructed. He introduced sophisticated electronics into the old solar telescopes to enhance their capacity to study the sun. At Kodaikanal Bappu's dream of setting up a full-fledged astrophysical institute and observatory began to take shape.

Bappu soon realised the unsuitability of the Kodaikanal location for year long stellar exposures. He trekked from Kanyakumari to Tirupati scouting for a suitable site and finally homed in on the Javadi Hill in Tamil Nadu. Here he found a plateau ringed by hills which created a stable atmosphere for observations near the sleepy village of Kavalur. Bappu set up the Kavalur Observatory with a 38-cm telescope. Later he installed a 1-meter Carl Zeiss telescope in this new observatory.

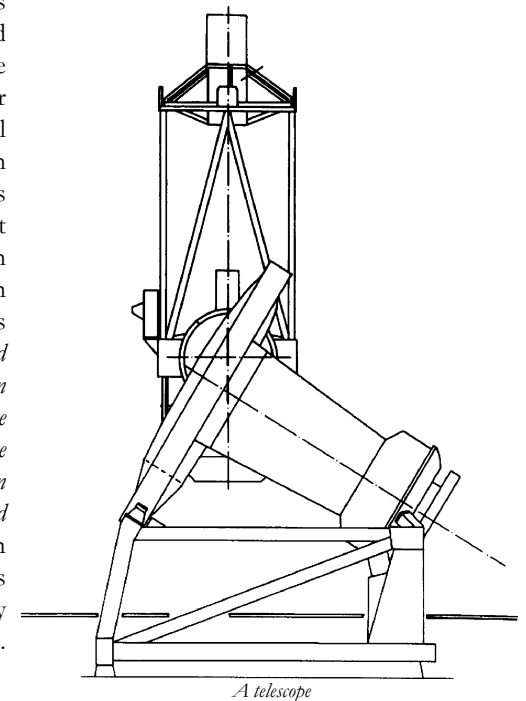
In 1971, the Kodaikanal and the Kavalur Observatories jointly formed an autonomous research centre – The Indian Institute of Astrophysics (IIA). This centre contributed enormously to astrophysical research in India. It had a strong theoretical group and an application group whose task



was to indigenously construct large optical telescopes in India. The IIA was started in the Raman Research Institute but soon shifted to its own campus in Koramangala, Bangalore. Bappu strove hard to make IIA a world class research centre. Within a fortnight of the installation of the Zeiss telescope, a rare occultation was observed at Kavalur. This provided evidence of a trace atmosphere in Jupiter's satellite - *Ganymede*. After a couple of years the same telescope discovered the rings of Uranus thus advancing our knowledge of the solar system. Bappu thus succeeded in creating an observatory with a world class capability.

Nobel Laureate S. Chandrasekhar visited the IIA in the early 1970's and was all praise for Bappu's accomplishments. Such a strenuous life took its toll and Bappu died prematurely at the age of 55 after a bypass surgery on August 19, 1982 just after being elected as President of the International Astronomical Union (IAU). His dream telescope (234-cm) was later dedicated to the nation by the then Prime Minister, Sri Rajiv Gandhi and the Kavalur Observatory was renamed the Vainu Bappu Observatory.

Bappu won many laurels during his multifaceted career. In 1970, he won the Shanti Swarup Bhatnagar Award for the Physical Sciences and the Hari Om Ashram Award in Physics in 1977. The Government of India honoured him with a Padma Bhushan in 1981. In one of his speeches he said, *"Time and again we have seen how an individual has appeared on the scene and transformed the picture of gathering confusion into one of logical rigour and aesthetic simplicity."* In uttering them he perhaps little realised that they very aptly mirrored his own life.



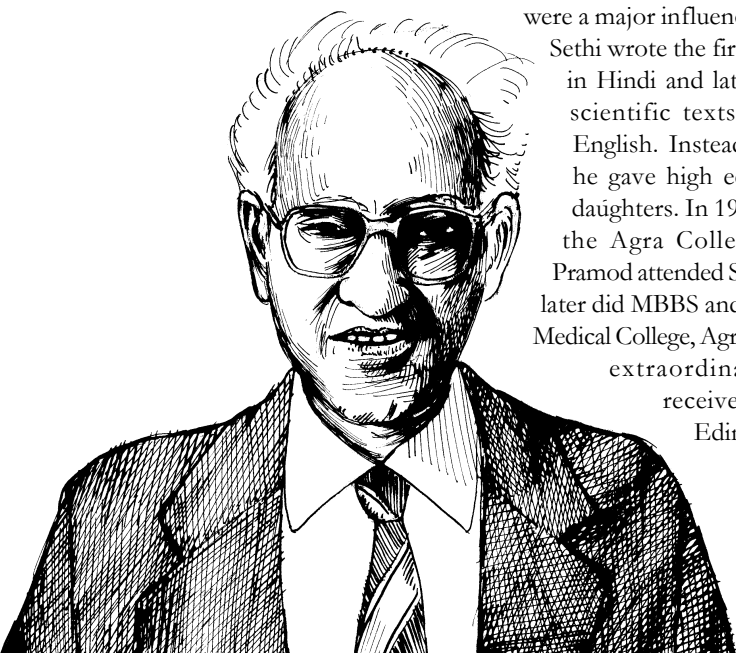


*"I have often advised our young doctors not to rush to make a lot of money – the gratitude of the patient should be enough." - P. K. Sethi*

Most people living in war zones – from Afghanistan, Sri Lanka to Rwanda are likely to know a town in north India – Jaipur. This city in Rajasthan is famous in strife-torn areas as the birthplace of an extraordinary prosthesis, or artificial limb, known as the *Jaipur Foot*. This low-cost attachment has revolutionized life for millions of land-mine amputees. It was co-designed by Dr. Pramod Karan Sethi.

Pramod spent his early childhood in Varanasi. His father Dr. Nikhil Karan Sethi taught physics at the Banaras Hindu University where scholarship, simplicity, sacrifice and service to the nation were encouraged. Gandhi's ideals were a major influence in the family. Dr.

Sethi wrote the first physics textbook in Hindi and later translated many scientific texts into Hindi from English. Instead of giving dowry, he gave high education to all his daughters. In 1930 Dr. Sethi joined the Agra College, so the young Pramod attended St. John's School and later did MBBS and MS from the S. N. Medical College, Agra. On account of his extraordinary brilliance he received his FRCS from Edinburgh in 1954.

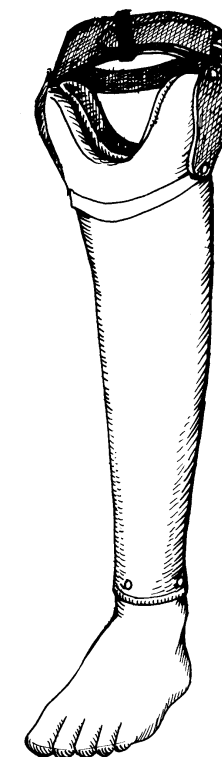


Though trained as a surgeon it was purely by chance that Pramod stumbled upon orthopaedics. A high powered team was to visit the Sawai Madho Singh Hospital, Jaipur for 'inspection'. As there was no Orthopaedic Department, the principal prevailed upon Pramod to start one. This expediency on the principal's part had more far reaching consequences than he could have envisaged, for Sethi went on to design a light, hard wearing, cheap artificial foot which transformed the lives of thousands across the world.

The *Jaipur Foot* was designed by an unusual team of a professional surgeon Dr. Pramod Karan Sethi – a fellow of Britain's Royal College of Surgeons and an unschooled master craftsman Ram Chandra Sharma. They both met 30 years back in the corridors of the Sawai Madho Singh Hospital in Jaipur where Sethi was helping orthopaedic patients with crutches and Sharma was teaching leprosy patients to make handicrafts.

Sethi wanted to provide an appropriate and inexpensive appliance for polio patients and amputees. The nearest artificial limb centre was in far away Pune or Mumbai where only the rich could go. So Sethi set up a workshop in the hospital premises to make some of the aids locally. The *foreign foot* made by the Army Limb Centre in Pune was heavy, stiff and had to be covered with a shoe. This resulted in people buying them but abandoning them very soon. The shoe presented most of the problems as Indians are used to walking barefoot in the fields, at home, at work and at places of worship. It was expensive and deteriorated rapidly when exposed to water or mud. In addition it severely limited postural flexibility. People could not sit cross legged or squat in the toilet.

Sethi was inspired by a Sri Lankan design where a rubber-foot like covering for artificial legs enabled farmers to work in water filled paddy fields. Sethi got a local craftsman to make a foot of vulcanized rubber. Initially it was heavy and stiff, but slowly it was modified by filling the shell with sponge rubber. Later they added microcellular rubber for the heel and cut wedges at its upper end to make a





universal joint. One patient's brother then dyed the rubber to an Indian skin colour, and this became the *Jaipur Foot*.

Trials of the *Jaipur Foot* demonstrated its durability, cost-effectiveness and comfort. The broad flat walking surface gave a feeling of security to the wearer. The tough rubber shell provided virtual immunity from breakdowns and most repairs to its surface could be made in the same manner that bicycle tyres were patched.

In 1970, Sethi presented his first paper on the *Jaipur Foot*. In 1974 he was asked to give the lead talk at the First World Congress on Prosthetics held in Montreux, Switzerland.

In 1975 Arjun Aggarwal, a wealthy former patient from Bihar donated a large sum of money toward the construction of a five-story rehabilitation centre on the hospital grounds. The state government and other philanthropists also pitched in help. The way poor patients are welcomed and treated at the centre is worth recounting. *"Patients arrive from all over without any notice, often accompanied by a close relative. The first thing they are asked to do is to telephone home informing their safe arrival. All food, care and medical facilities are free. A simple kit containing*

*toilet articles, a plate, a mug and a towel is given to each amputee. Thus equipped, the patient enters the rehab centre's courtyard. The courtyard is alive with other amputees - peers who understand him and respect his individuality and the communal experience helps build his confidence and self-esteem. Once treated the patient is given a free train ticket along with a packet of food to return home!"* (Extract from Magsaysay citation)

The process of making and fitting a new limb takes an hour. Each limb is tailor made to suit the specific needs of the patient. Wearing this limb a person can work in the fields, climb trees, pull rickshaws, walk on uneven ground or even perform a traditional dance. In Western countries most amputees are old, where as in India most patients are young and poor migrant labourers.

In 1978, Sethi received the B.C. Roy Award as an *Eminent Medical Teacher*, and the Padma Shri honour from the Indian government in 1981. The same year he was also awarded the prestigious Ramon Magsaysay Award for Community Service.

Dr. Sethi was a man of deep scholarship. He was keenly interested in trees and flowering plants. He was a prolific reader and loved listening to classical Indian ragas, Western jazz, early rock and folk music. He never joined any social club or took a vacation, preferring to spend his leisure at home with his family – his wife Sulochana, three daughters and a son. Dr. Sethi passed away on 6 January 2008 at the age of 80.

A documentary on the *Jaipur Foot* was made by David Suzuki for the Canadian Broadcasting Corporation. The *Jaipur Foot* was also immortalised in *Nache Mayuri* a Bollywood blockbuster about Sudha Chandran, a young Indian classical dancer on the verge of a glittering career who lost a leg. Her rehabilitation and subsequent success in Indian cinema was attributed to the *Jaipur Foot*. School going children in India will be able to read about the dancer and the *Jaipur Foot* in the Class 3 English text book.



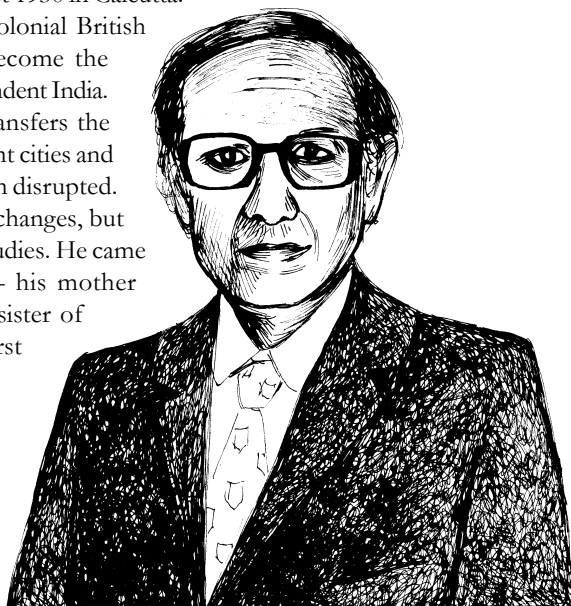
Sudha Chandran





Today liquid crystals are used for a variety of electronic displays - from mobiles to wide-screen televisions. They have replaced Cathode Ray Tubes and have become the quintessential molecular material for electronic displays. The development and research into liquid crystals has been due in no small measure to the pioneering work of Sivaramakrishna Chandrasekhar, known affectionately as *Chandra*.

Chandra was born on 6 August 1930 in Calcutta. His father worked for the colonial British Government and rose to become the Accountant General in independent India. As a result of his father's transfers the family often moved to different cities and Chandra's schooling was often disrupted. Chandra did not enjoy these changes, but despite this did very well in studies. He came from an illustrious family – his mother Sitalakshmi was the younger sister of Sir C. V. Raman – India's first science Nobel Laureate. His younger brother S. Pancharatnam (of the Pancharatnam phase) died at a young age. His elder brother Prof. S. Ramaseshan was also a

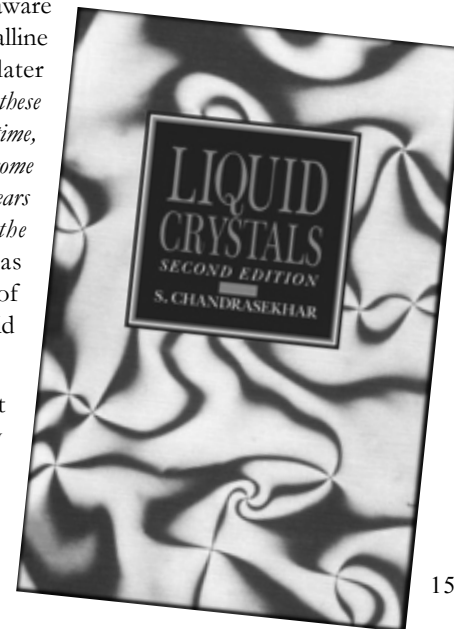


very distinguished scientist. In 1951, Chandra topped the Nagpur University's MSc exam receiving two gold medals and later a PhD.

Later he moved to Bangalore to join the newly opened Raman Research Institute. He was the first research scholar of his famous uncle Sir C. V. Raman, but their relationship was always that of teacher and student and never of uncle and nephew. It is about this time that he met his future wife Ila at the house of his elder brother Prof. Ramaseshan. Despite a small research fellowship Chandra managed to buy a motorcycle and rode with Ila on the pillion, causing quite a stir in the conservative scientific community! Unfortunately, he met with an accident and had a head injury which gave him innumerable headaches for the rest of his life. Because Chandra and Ila spoke different languages and came from different regions there were some problems before marriage. But they were soon sorted out.

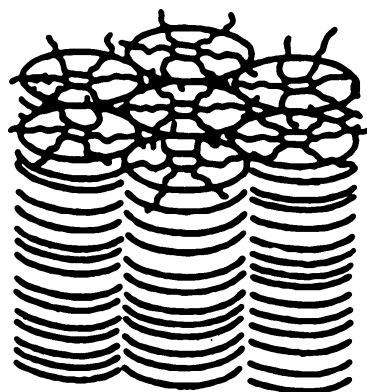
Soon after marriage Chandra won a scholarship and left for the Cavendish Laboratory and obtained a second doctorate degree from the Cambridge University mainly on X-ray scattering from crystals. On returning to India in 1961 he became the first Head of the Department of Physics at the University of Mysore. The department was located in a wild patch belonging to Princess Leelavathi of the Mysore royal family. Even after clearance the land was still frequented by jackals, owls and even leopards. It was here that Chandra got interested in *liquid crystals* – a hitherto neglected field of research. At that time, very few scientists were even aware of the existence of liquid-crystalline materials. Chandra himself later admitted that "*my knowledge of these intermediate phases was, at that time, limited to the brief accounts I had come across as a student more than ten years earlier in books published in the 1930s*". Nevertheless, he was determined to change his field of research from solid state to liquid crystals.

After a sojourn in Britain, at Cambridge and University College London, Chandra moved in 1971 to the Raman Research Institute in



Bangalore. There he established a liquid-crystals laboratory with some of his former students that soon became an outstanding school. Realizing that cutting-edge research would not be possible without an in-house capacity to produce new materials, an organic chemistry laboratory was also added. Soon new research from the Liquid Crystal Laboratory at RRI made it one of the leading centres of research in the world. The pinnacle in Chandrasekhar's scientific career came in 1977 when he and his co-workers discovered a new type of liquid crystal made of new type of molecules. These molecules had the shape of discs rather than the well studied rods. This discovery made Chandra internationally famous. The paper announcing the discovery of the *discotic* liquid crystal was published in *Pramana*, and is one of the most highly cited papers in the field of liquid crystals.

About 1,500 new *discotic* compounds have since been synthesised in laboratories throughout the world, and nearly 2,000 papers have been published describing their physical and chemical properties. They are being developed for use in a range of technologies including xerography, solar cells, optical storage devices, and hybrid computer chips.



Schematic diagram of the structure of a columnar discotic liquid crystal.

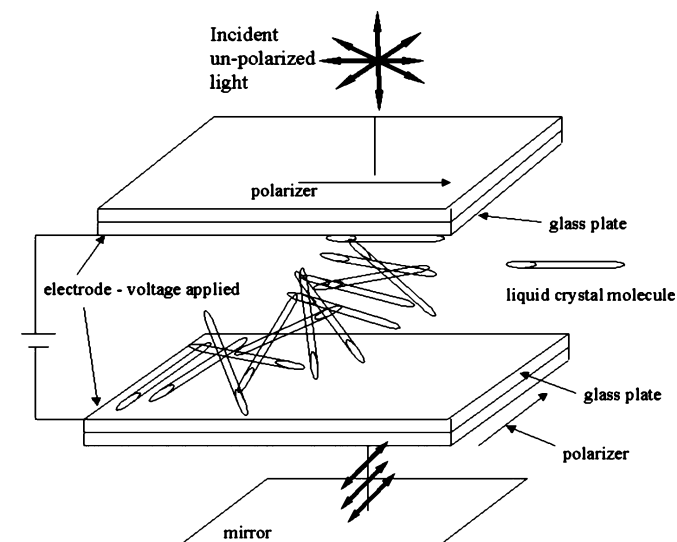
Liquid crystals among other things help in explaining the functions of biological structures, such as living tissues, and knowledge of them is crucial for an understanding of biological membranes. Biologists, pharmacists and medical researchers are therefore among those interested in liquid crystal research. They all owe a debt of gratitude to Chandrasekhar.

In 1977, the Cambridge University Press published Chandrasekhar's book *Liquid Crystals*. This has become a bible for any serious scholar on the subject. This book has already been translated in Japanese and Russian. An enlarged second edition of this acclaimed classic was published in 1992.

Chandrasekhar also organised several international conferences, including the one in 1973 on the occasion of the Silver Jubilee of the founding of the RRI. After retiring from the RRI in 1990, Chandrasekhar started the Centre for Liquid Crystal Research in a building made available by the Bharat Electronics Limited.

Chandrasekhar's scientific achievements brought him many honours. He was elected fellow of all the three academies in India. He was elected as a Fellow of the Royal Society (1983), of the Institute of Physics (London) and of the Third World Academy of Sciences. He was the founder president of the International Liquid Crystal Society during 1990-92, and edited the journal *Molecular Crystals and Liquid Crystals* for over two decades. He received numerous awards – prominent among them being the Bhatnagar Prize (1972), Homi Bhabha (1987) and Meghnad Saha (1992) medals of INSA, the Royal Medal (1994), Niels Bohr Gold Medal of UNESCO (1998) and the Padma Bhushan Award in 1998.

Because of his ill health he was advised to slow down a little. So he relaxed at home and enjoyed all the visitors who called on him. As his health improved he was again full of enthusiasm and was planning trips to various conferences and meetings. Unfortunately, he died of a stroke on March 7, 2004. He was survived by his wife Ila, son Ajit and daughter Indira.



Liquid crystal displays are now used in clocks, computer monitors and TV screens.



*"If we care for the poor, we cannot allow the Gross National Product to destroy the Gross Nature Product any further."*

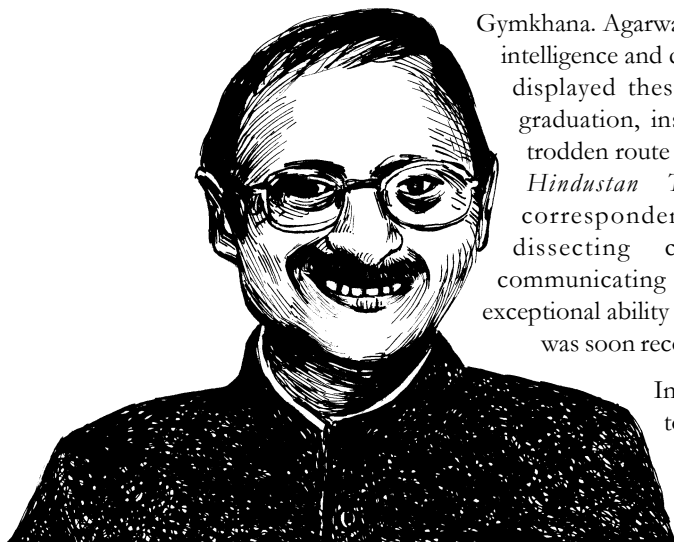
*- Anil Agarwal: WWF, London, October 8, 1985*

Anil Agarwal was a prominent Indian environmentalist – perhaps the first to see the problem through the eyes of the poor. The poor – because of their fast population growth were blamed for degrading the environment and rapid deforestation. Agarwal challenged these notions. He felt that the poor had a great stake in the responsible management of the environment.

Anil Agarwal was born in a business family of Kanpur. In 1970 he got a degree in mechanical engineering from I.I.T. Kanpur. He was a fiery orator and was elected as the President of the Student's

Gymkhana. Agarwal was a man with a sharp intelligence and deep commitment and he displayed these traits early on. After graduation, instead of taking the well trodden route to the USA he joined the *Hindustan Times* as a science correspondent. He had a flair for dissecting complex ideas and communicating them with clarity. This exceptional ability for lucid, brilliant writing was soon recognized.

In the mid 1970's he went to England and came under the influence of Barbara Ward – the high priestess of the environment and



author of *Only One Earth*. After gaining sufficient international exposure Agarwal returned to New Delhi in the early 1980's and founded the Centre for Science and Environment (CSE).

The staggering breadth and depth of Agarwal's concerns were demonstrated first in *The State of India's Environment 1982: A Citizen's Report*. In compiling this report he was helped by numerous grassroots movements and field activists. This landmark book was the first serious overview of the use and abuse of nature in India. The book honestly and attractively documented the reality of India's environmental degradation. It got an overwhelming response and was reviewed in hundreds of journals worldwide!

The *First Citizen's Report* came as an eye opener for insular academicians, blind state and sleepy public. It examined the ecological burden borne by women in dealing with a declining biomass-based rural economy. This helped in understanding the relationship between environment and development. Its contents were discussed and acted upon. It had a far reaching impact. The book was translated in Kannada and Hindi by famous environmentalists Shivaram Karanth and Anupam Mishra.

Subsequent Citizen's Reports followed. In *The Politics of the Environment* Agarwal argued for a holistic management of land and water resources in the country. The third report focused on floods and the fourth appropriately titled *Dying Wisdom* documented India's traditional water harvesting methods. While the first two reports drew on field reports of scores of activists the latter were produced in-house, reflecting the slow fading of CSE's links with mass movements.

In *Towards Green Villages*, Agarwal emphasised decentralised control by village communities as a strategy for environmentally sound and participatory rural development. The CSE documented and brought into prominence initiatives such as *Sukhomajri* in Haryana, *Ralegan Siddhi* in Maharashtra and the *Tarun Bharat Sangh* in Rajasthan as holistic experiments in land-water management.

Agarwal did not trust political parties or trade unions as agents of change, but preferred to pin his hopes on grassroots organizations which he believed could pressure the state into action. When Rajiv Gandhi became the prime



*A caricature of Anil Agarwal  
by Rustam Vania*

minister, he invited Agarwal to brief the Cabinet and senior bureaucrats on environment and development issues. Rajiv Gandhi felt that sensitising key politicians could positively impact the environment.

At the time when wanton pollution caused by vehicular exhaust was choking Delhi, Agarwal mounted a sustained and hard-hitting campaign through the publication of *Slow Murder*. This report brilliantly pinned responsibility on fuel refineries, auto manufacturers and regulatory authorities. This analysis was followed by a concerted media campaign which finally led the Supreme Court to order the phasing out and conversion of polluting vehicles in Delhi. Agarwal marshalled solid evidence and embarrassed many corporate firms for shamefully polluting the environment. Soon the entire public transport in Delhi switched to compressed natural gas (CNG). If people in Delhi breathe a little easy today it is thanks to Anil Agarwal.



Agarwal founded the fortnightly environmental magazine *Down to Earth* with a wonderful children's section titled *Gobar Times*. The CSE has often taken up high-decibel campaigns against the high-handedness of corporations and forced the government to set-up regulations and enforce them. As a fiercely independent environmental watchdog the CSE founded by Agarwal has done commendable public service to the country.

In 1989 Agarwal co-authored a pamphlet *Global Warming in an Unequal World*. This showed that the *survival emissions* of the poor – the methane released by rice fields was different from the *luxury emissions* of the rich – toxic gases released by their military-automobile-industrial complex. The West sought to blame the victims and reward the polluters. The rich Western countries accused underdeveloped countries like India and China for global warming and exhorted them to clean up their act. Agarwal termed it as *environmental colonialism* and urged the West to own up its historical responsibility for greenhouse gases. It was foolish, he argued to divide the *carbon sink* provided by the oceans and atmosphere in proportion to the magnitude of greenhouse gases currently being emitted by *each country*. A more equitable way would be to allocate each human being an equal share of the carbon sink.



Agarwal received several honours for his work. IIT / Kanpur bestowed the Distinguished Alumnus Award on him. In 1987, the United Nations Environment Programme elected him to its Global 500 Roll of Honour. The Indian Government honoured him with a Padma Bhushan for his work in environment and development.

For more than twenty years Anil Agarwal was India's most articulate and influential environmental campaigner. He possessed an uncanny ability to synthesize the results of specialized scientific studies and to communicate them in simple language. He believed in not just highlighting environmental problems but in finding just solutions.

Agarwal possessed an almost heroic determination. He conducted a long battle against chronic asthma, and then in 1994 was diagnosed with a rare form of cancer which affected the eyes and brain. From his sick bed, while in remission he planned and carried out his last campaign. He died prematurely at the age of just fifty-four in Dehradun on Jan 02, 2002.



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